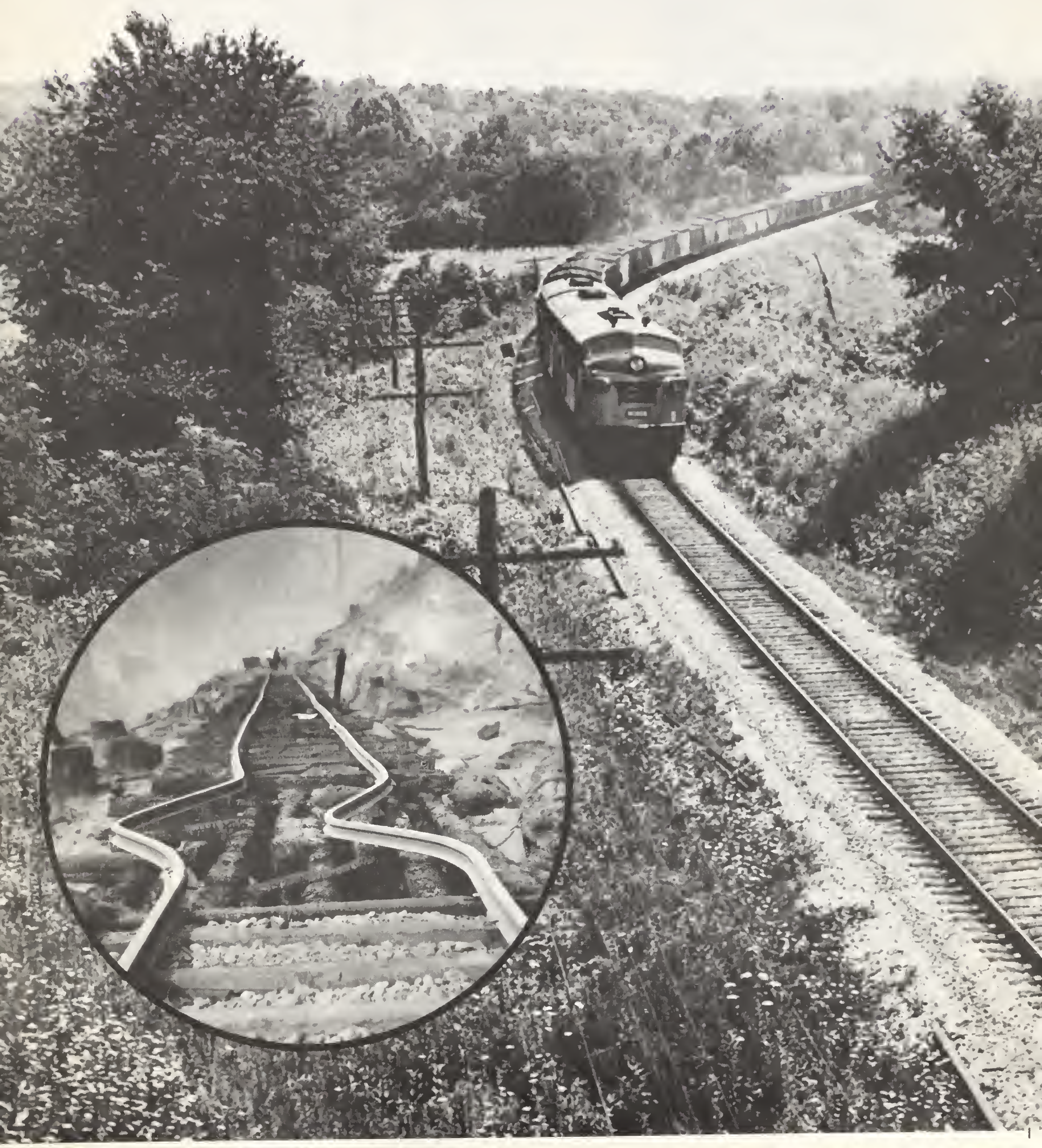
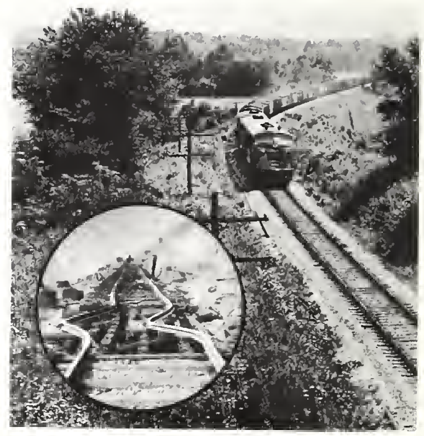
FIRE MANAGEMENT

SPRING 1974 Vol. 35, No. 2
U.S. DEPARTMENT OF AGRICULTURE • FOREST SERVICE



FIRE MANAGEMENT

An international quarterly periodical devoted to forest fire management



Railroads are an important cause of wildfires, but New York has found a way to reduce the number. See story, next page.
NOTE: The track buckling was caused by a burning trestle, picture by R. E. McArdle, 1926, State of Washington.

FIRE MANAGEMENT is issued by the Forest Service of the United States Department of Agriculture, Washington, D.C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication is approved by the Director of the Office of Management and Budget (Oct. 17, 1973).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402, 45 cents, or by subscription at the rate of $1.50 per year domestic, or $2.00, foreign. Postage stamps cannot be accepted in payment.

NOTE—The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such does not constitute an official endorsement or approval of any product or service by the U.S. Department of Agriculture to the exclusion of others which may be suitable.

Wildfire burns parallel to the track; this is one of 2,123 railroad caused fires in the 20 States of the Forest Service eastern region during 1972. The number of these fires in New York was dramatically reduced to only 43.

Statistics tell . . .

New York Reduces Railroad Fires

Robert M. Loomis, Charles R. Crandall, and Richard W. Mullavey

Proponents of the adages that "statistics don't lie" can cite what has happened since the New York Department of Environmental Conservation's senior locomotive inspector became involved in a research role.

The logic for pioneering such an assignment in this Department's operations had been pinpointed by the USDA Forest Service when in 1964 it began separately listing railroad-caused fires. The figures have been "speaking out" an encouraging message for New York listeners. For example, 2,123 wildfires occurred during 1972 burning 7,624 acres in the Forest Service's 20-State Eastern Region, all attributed to railroading operations.

Of these, only 43 fires that burned 288 acres occurred in New York. This was in marked contrast to what has been a worrisome fire history for citizens of this State during the last half of the 1960's, when the annual number of wildfires caused by railroads never fell below 80 and zoomed to 101 in 1969. Moreover, it also marked the continuance of a downward trend in the 2 years following 1969; the number of railroad caused fires dipped to 68 in 1970 and to 71 in 1971.

A Fire Prevention Success

This success story might very well be linked to the cooperative fire prevention efforts that the New York Bureau of Forest Fire Control developed during the last 4 years with the six major railroads and a number of smaller lines operating within the State.

For example, a 30-day maintenance program for cleaning spark arresters on locomotives was initiated; recording devices to detect defective brakeshoes and hotboxes are now being used by more of the railroads; and a concerted attack is being maintained to identify and

Railroad, p. 5

Robert M. Loomis is fire control scientist, North Central Forest Experiment Station, USDA Forest Service, East Lansing, Mich.; Charles R. Crandall is senior locomotive inspector, Department of Environmental Conservation, Hornell, New York; and Richard E. Mullavey is prevention staff specialist, Forest Fire Management Group, State and Private Forestry, USDA Forest Service, Upper Darby, Penn.

Comparison Tests . . .

Fireplow Out-performs Vehicle-drawn Flail Trencher

Robert J. Knudson and Lynn J. Horton

The fireplow is used with great success in the Forest Service Southern and Eastern Regions. Widely held opinion has been that western terrain is too rough for its use. Is this really true?

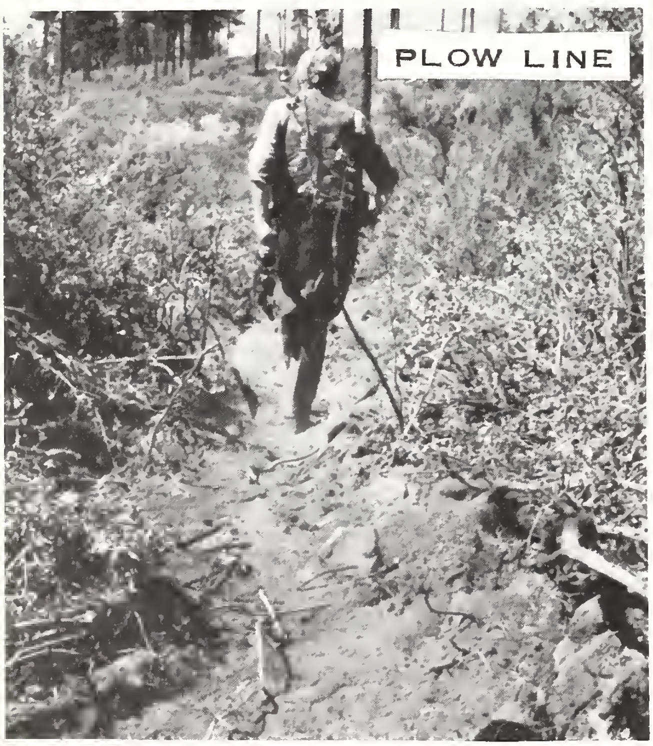
Recent tests show that the fireplow is superior to the trencher and that it can be used on much of the western terrain.

A direct comparison of the fireline production capabilities of the two machines was carried out on the Modoc National Forest, Calif. To assist in carrying out the tests, two operators and fireplow units were assigned to the Modoc for 6 weeks during the late summer of 1972. The plow unit was complete and included a Caterpiller D4E tractor, a Mathis fireplow, Model P-2-H, and a transport truck equipped with a tilting and sliding bed.

The trencher was the Missoula Equipment Development Center (MEDC) prototype No. 1 trailer-style trencher, using a 24-hp engine and mechanical drive. Towing vehicles for the trencher were a D4D Caterpiller tractor and a 1-ton 4x4 International tanker pickup, both supplied by the Modoc. Before the evaluation, MEDC personnel installed trencher controls and accessories and instructed Modoc NF personnel in the operation of the trencher.

Procedure

The tests were run on the Double-head District, Modoc National Forest, near the Dry Lake Guard Station on ground that varied from level to slopes of 35 percent. Vegetative cover included grass, light to heavy sagebrush, bitterbrush, ceanothus or manzanita, and light timber. Patches of loose rock



Ten percent to 15 percent sidehill with heavy cover of manzanita and bitterbrush. Considerable rock up to about 12 inches.

	Plow	Trencher
Line length	1250 feet	Too tough for trencher
Time	17 minutes	
Speed	¾ m.p.h.	

Line quality results

Plow	Good 3-foot line + berm. Occasional brush fell back into line from uphill side. Operator limited speed to reduce chances of damage to plow.

up to about 12 inches in size were frequently encountered in all areas. Test firelines were built by both machines, with the trencher line near and parallel to the plowline. Line length was determined by pacing; times to build the lines were recorded by the machine operators; slopes were measured with an optical clinometer; and judgment evaluations of ground and vegetative conditions and line quality were made by MEDC personnel.

Four line quality criteria were used:

Excellent. Very nearly perfect with very little or no vegetative material left in the line. No extra handwork required.

Good. A small amount of vegetative material left in the line, either unexcavated or that which has fallen back into the line. No continuous bridge of vegetation across the line. Very little extra handwork required.

Fair. More vegetation left in the line than a good line. Occasional bridging of the line by continuous vegetation. Handwork required to complete a clean line.

Nearly ineffective. Bridging of the line by vegetation is frequently encountered. Handwork required is about one-half or more of that required to build an excellent line by hand.

Significant tests, with descriptions of the terrain and vegetative cover, are described in tables.

Fireline Construction Speeds.

The plowing speeds do not necessarily represent the maximum possible plowing speed for the given condition. Plowing speeds were determined by the operator's judgment of prevalent conditions. Poor forward visibility in brush necessitated reductions in plowing speeds to avoid hidden ledges, rocks, and other obstacles. In more open areas, the operator reduced speed to avoid damage to the plow from impact with subsurface rocks. The plowing speeds shown should therefore be viewed as prudent speeds for the test conditions.

Line construction speeds for the trencher were always determined by the trencher engine speed. The driver of the towing vehicle listened to the exhaust sound of the trencher engine and adjusted the forward speed to maintain high r/min.

Although the average line building speeds determined from this elevation are based on limited testing, they provide an indication of the comparative effectiveness of the two machines. Within the limits of accuracy of the data obtained from these tests, the plow averaged overall about 2 mi/h. On areas where the plow and trencher both worked, the plow averaged about 3 mi/h, while the trencher averaged about 1 mi/h.

Typical Lines

As well as always building fireline faster, line quality produced by the

Fireplow, next page

Robert J. Knudson is a mechanical engineer at the Forest Service, Missoula Equipment Development Center. Lynn J. Horton is fire management officer, Modoc National Forest, Calif.

Railroad, from p.3

eliminate hazardous vegetation along rights-of-way.

Since spark arrestor maintenance was initiated in 1970, only five fires started that could be attributed to engines that had incandescent carbon build-up in stacks. Previously, this had been the source of 75 percent of the railroad-caused fires in the State. All five engines had been used for "way freight" operations, and the fires all occurred within 4 days before these engines were scheduled for the shop under the 30-day maintenance program. This experience showed that spark arrestors on engines used for "way freight" operations should be cleaned at intervals of less than 30 days. This makes sense because two factors contribute to faster buildup of carbon during such operations: (1) locomotives are idle for long periods and (2) locomotives often are used to haul heavier loads than for which they were designed.

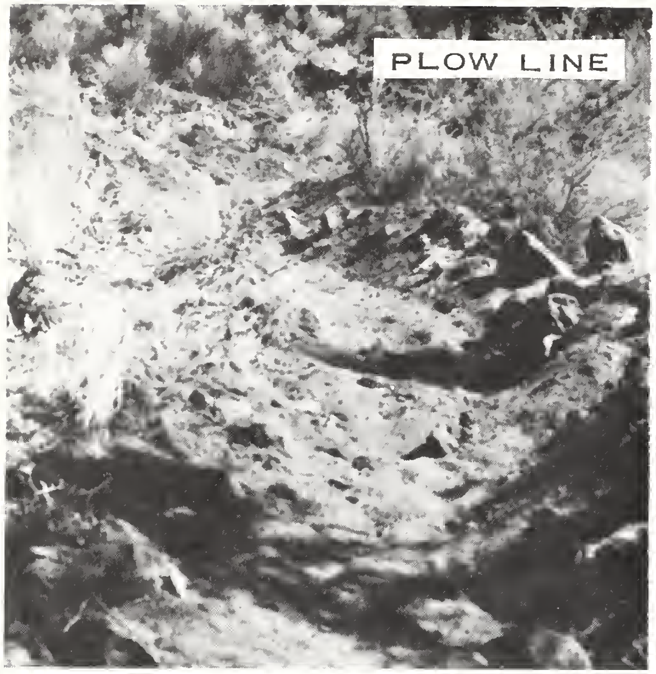
Heat Sensors Detect Fire Potential

Heat sensors are used to detect defective brakeshoes and hotboxes. These are located at strategic points along the track, as close as 25 miles apart. They transmit temperature readings to recorders usually located in dispatchers offices. They pinpoint unusually high temperatures and identify their source as to individual car, side of track, and specific wheel.

Continual inspection of rights-of-way for hazardous vegetation is one of the vital gaps filled by the State inspector. Upon spotting such areas, he involves the appropriate railroads in the planning and execution of corrective treatments.

Although controlled burning during the spring is still the primary treatment used, its limitations —suitable weather, potential for escape, and air pollution—prompted a limited test of phytocide chemicals to determine their effectiveness in soil sterilization for breaking the continuity of natural vegetation. To do this, a cooperative study was set up with the USDA Forest Service. Results of this study indicate that the most practical approach is to apply these chemicals in strips of widths related to the height of surrounding vegetation. The economic feasibility of such treatments has not been evaluated.

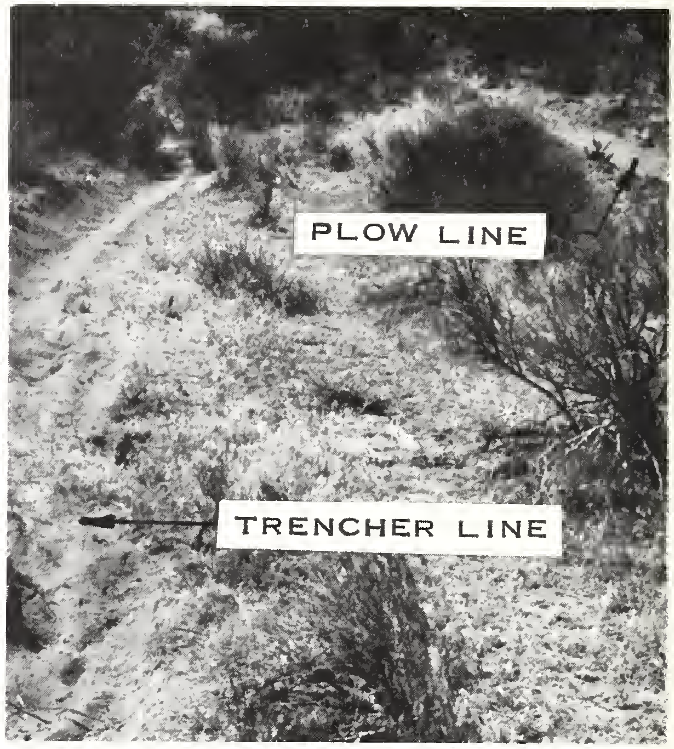
New York has reduced railroad fire occurrence, but the challenge remains not only to hold gains made, but to continue looking for new fire prevention ideas. For example, information is needed on carbon particles emission from stacks, spark burnout time, and relationship of topography on ignition. New York is moving ahead with a pilot project to measure the significance of these factors.



	Varying slapes from 10 percent to 30 percent. Cover varied from light grass to fairly thick brush. Much 6- to 12-inch rock in the soil + a 2- to 3-foot high rock ledge. Worked upslope and dawnslope.	
	Plow	Trencher
Line length	900 up (feet) 800 dawn	
Time	12 up (min.) 8 down	
Speed	¾ up (m. p. h.) 1-1/8 dawn	

Line quality results

Plow	Good line both uphill and downhill, except across the rock ledge.
Trencher	Too steep. Broke coupling. Some good line built at a slow rate on gentle slope before breakdown.



	Flat ground, occasional patches of 8- ta 12-inch racks, fairly thick cover of sagebrush and bitterbrush. Two feet to 4 feet high.	
	Plow	Trencher
Line length	4400 feet	1200 feet
Time	20 minutes	17 minutes
Speed	2-½ m.p.h.	¾ m.p.h.

Line quality results

Plaw	Gaad to excellent 3-faot line with 1-foot ta 1-½-faot berm = 5-faot to 6-foot total width.
Trencher	Poor to gaod 1-½-foot to 2-foot line + 20-faat dust cast, left some stems in line through thicker stands of brush.

Fireplow, from p. 5

plow was always superior to the trencher. A typical line built by the plow was a flat-bottomed trench about 3 feet wide, with berms on both sides of the trench. The berms were 1 foot to 1-½ feet wide and consisted of overturned soil and vegetation removed from the trench. For other than large brush, the removed vegetation was buried by the berm. Thus, the total width of exposed soil was 5 to 6 feet.

The typical trencher line was 1-½ to 2 feet wide, plus a 10- to 30-foot wide area which was coated by dust thrown by the flails. The dust coating on vegetation has shown that it has a retardant effect in reducing the rate of spread of a fire. Variations in the width of coated vegetation depends on the soil.

Coarse soil will produce a wide, but lighter coating, while soil that has predominately very fine particles will produce a heavier coating on a narrow area along the line.

Reliability

The trencher required a transmission adjustment and had two breakdowns during the testing, and since the tests were all run in a 3-day period, there was no opportunity to repeat the missed tests. The shaft couplings, which had given 2 years of service, between the clutch and transmission and between the transmission and the final drive, each broke.

A relatively new type of Delrin link chain was used on the couplings in lieu of conventional steel roller chain because the Delrin is impervious to abrasion by dust and dirt and requires no lubrication. Several links of the coupling failed simultaneously, indicating a general weakening of the entire chain, possibly caused by ultra-violet degradation from 2 years of exterior storage and use. The first broken coupling chain was replaced by a steel roller chain, which put the machine back in service until failure of the second coupling.

No failures occurred with the fireplow. The plow is a simple, rugged unit which has no powered components except for the tractor-powered hydraulic cylinder which raises and lowers the digging components relative to the wheels.

Waterbar Building with Plow

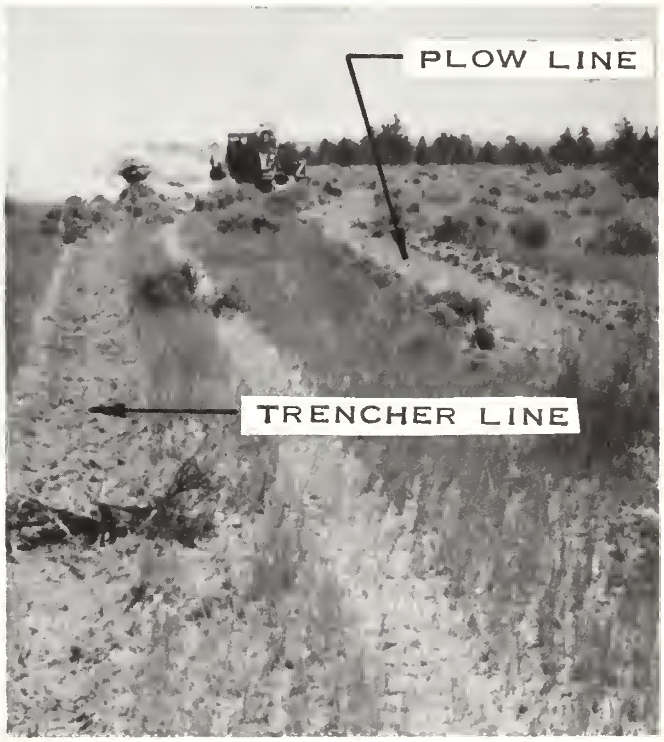
Attempts were made to construct waterbars with the plow on pre-attack lines which were built before the comparative evaluation. The waterbars were built on side slopes of up to 35 percent. The plow is designed to operate parallel to the ground and cannot be tilted like a dozer blade for ditching; this resulted in very poor and ineffective waterbars. In addition, the plow–tractor unit is very long and has to

Fireplow, next page

	Flat ground, tough bunch grass.	
	Plow	Trencher
Line length	7600 feet	2150 feet
Time	20 minutes	20 minutes
Speed	4-¼ m.p.h.	1-¼ m.p.h.

Line quality results

Plow	Good to excellent 3-foot line + 1-foot to 1-½-foot berms. Total width = 5 feet to 6 feet. Left 1-inch to 2-inch wide rows of grass bunches between middle-buster and disc-built portions of the line.
Trencher	Fair to poor 1-½-foot line + 20-foot dust cast. Did not dig out tougher grass bunches.



Fireplow, from p. 7

move a long way off the line and knock down trees which had been missed in line plowing. It was the judgment of the people on the site that hand construction of waterbars would have been better.

The Southern Region tractor was not equipped with a dozer blade on the C-frame because of overwidth limitations for highway transportation on the home district of the plow. Also, the complete unit with blade attached is too long for the truck bed of the vehicle used. A device was mounted in place of the dozer blade and used for pushing stumps and brush out of the way.

Where transport restrictions allow it, the dozer blade should be retained on the tractor and used for waterbar building. The plow could also be detached and the dozer blade used for line construction on ground that is too steep or rocky, or where vegetation is too large for effective plowing.

Project and Fire Work

Prior to the comparison tests, the tractor–plow was used for preattack fireline construction in the Sugar Hill portion of the Modoc National Forest. Parallel strips were plowed to increase effective width of the line.

Vegetation in the Sugar Hill area is coniferous timber, grass, and light to medium brush. The tractor-plow exhibited fair maneuverability among 30- to 35-year-old pine stands. However, it uprooted some trees along the plowed line, creating additional work in removing damaged trees. The plow cut a good 3-foot line through the brush, with dirt sidecast for an additional 1 to 2 feet on each side, making an effective line width of about 6 feet.

Slope ranged from nearly level to about 35 percent. The tractor–plow was able to negotiate the steeper slopes in straight up–straight down fashion. The D4, however, lacked sufficient power to work up the 30- to 35-percent slopes easily.

Tractor–Plow Fire Performance

The unit was used on two fires during the period of time the tractor–plow unit was assigned to the Modoc National Forest.

August 7, 1972—The tractor plow was dispatched to a 3,940-acre fire near Herlong in Bureau of Land Management's area of jurisdiction. Vegetation was grass and sparse sage. Slopes averaged about 20 percent with some to 30 percent. Surface material was very rocky, with rocks averaging 12 to 24 inches.

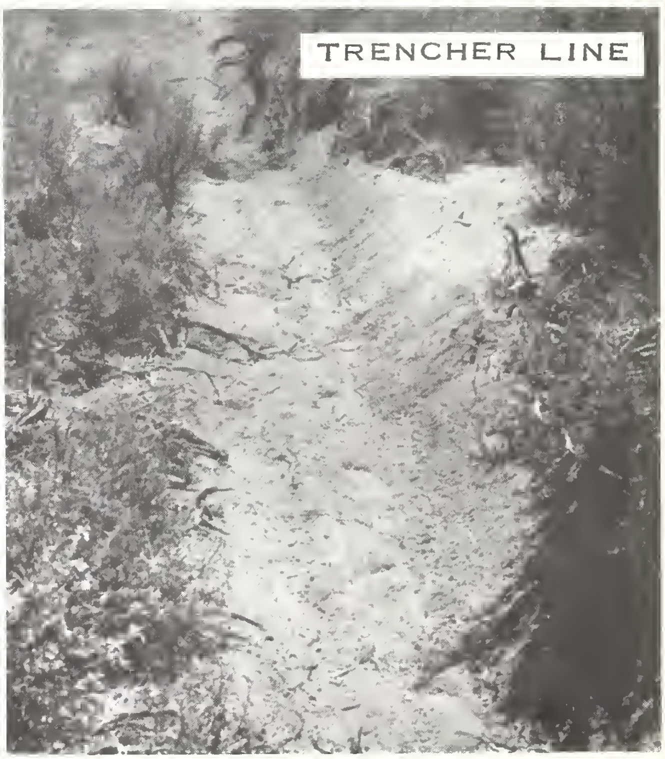
During daylight hours the tractor–plow made very good time while constructing single width cold trail fireline. The machine outdistanced two D8 tractors on this fire. During evening hours the unit encountered rock which it couldn't negotiate and the machine was no longer used.

August 10, 1972—The plow unit was used on the Westlake Fire near Canby, Calif. This was an 83-acre fire. Slopes ranged from 20 to 25

	Level area with some 5 percent to 10 percent slopes. Grass and moderate sagebrush cover. Many patches of loose rock up to 12 inches.	
	Plow	Trencher
Line length	2250 feet	1200 feet
Time	20 minutes	20 minutes
Speed	1-¼ m.p.h.	¾ m.p.h.

Line quality results

Plow	Good line, 5 feet wide, including berm. Operator restricted speed to minimize chances of damage to plow.
Trencher	Good 2-foot line with 10-foot dust cast.



percent. Surface material was rocky. Vegetation was dense, medium sized brush.

Fireline had already been constructed by the Forest's D4 bulldozer by the time the plow arrived. The unit was assigned to widen this line. However, nearly continuous 12-inch and larger rocks, and 20- to 25-percent slopes, caused poor performance and a blade was required. Work with the plow was discontinued on this fire.

Mopup

Both the plow and the trencher distrub less vegetation than a bulldozer. The smaller tractors are better able to thread their way between trees, and therefore knock down fewer trees than larger dozers. Neither the plow nor the trencher moves enough dirt to bury the quantity of fuel that is buried in dozer line berms. Thus, neither the plow nor the trencher will create mopup problems that dozers do.

Plow-type Comparisons

The study reported here concerned only the Mathis plow, but there are several other makes and models of fireplows which have not been evaluated by MEDC. Plow features have been discussed with users and literature examined pertaining to a variety of plows. Sieco plows, for example, are mounted directly on tractors with special hitches built to fit each of the various makes and models of tractors. A tractor with a Sieco plow is a shorter, more maneuverable unit than the Tractor-Mathis plow unit. Because the Sieco plow may be hydraulically elevated, leaving only the tractor tracks on the ground, a Sieco plow unit may be better suited to heavily timbered areas and waterbar building.

The selection of a fireplow-type, trailor vs. tractor-mounted, should be based on other factors as well as maneuverability, such as:

The tractor winch may be retained with the trailer-style plow. The Sieco plow requires a special hitch which leaves no room for a winch.

The trailer-style plow is very rapidly attached to the tractor. About 1-½ minutes are required for one man to attach the tongue to the tractor drawbar and connect two hydraulic quick couplers. The tractor is therefore available for project work, and if the plow is nearby, it is immediately available for fire duty. The manufacturer of the Sieco plow estimates that 10 minutes' work for two men is required to remove the Sieco plow, leaving the special hitch on the tractor.

A longer transport is required for the trailer-style tractor–plow unit. Southern Region has a very good solution to the transport problem with their tilting and sliding bed on a tandem axle truck. Figure 2 shows the Mathis plow with the transport bed in the load or unload position. Figure 3 shows a Sieco plow-equipped tractor being loaded on a small tilting and sliding bed transport.

Conclusion and Recommendations

1. The fireplow demonstrated a clear superiority over the trencher.
2. The mechanical simplicity and ruggedness of the plow insures high reliability with minimum upkeep.
3. The plow is useful in terrain with slopes up to at least 30 percent in vegetation from light grass to dense medium sized brush, and in a variety of soils, including those containing considerable rock 12 to 14 inches in diameter.
4. The fireplow is especially fast in range-type fuels.
5. The fireplow should be tried in other western forests with operators trained by experienced plowmen. Both trailer-style and tractor-mounted plows should be tried.
6. An educational program should be initiated, based on the experience of the Modoc, to acquaint fire management specialists in the Western Regions with the merits of the fireplow.
7. Further development of flail-type, vehicle-mounted trenchers should be terminated.

Brown and Davis Revise Textbook

"Forest Fire Control and Use," (McGraw Hill), a definitive 650-page college textbook on management of fire in forestlands, has recently been revised and updated by Arthur A. Brown in collaboration with Professor Kenneth P. Davis of Yale University.

First edition of the book, published in 1959, was authored by Professor Davis alone and bore the dedication, "To the men of the U. S. Forest Service who through pioneering experience and creative research have formed the art and science of forest fire control."

Taming the Dragon

Arthur A. Brown has devoted a professional lifetime to understanding and taming that rapacious dragon, the forest fire. Nearly half a century of pioneering experience and creative research has gone into his work on the newly-revised textbook.

While still a student at the University of Michigan—from which he graduated with bachelor of science degree in forestry in 1922—Brown served as fire guard on the Bitterroot National Forest in Montana. He continued his work in the Forest Service, and when the Forest Service created a fire research division in 1948, Brown, then Chief of Fire Control in the Washington, D.C. headquarters, was named to head it up. Under his direction, a program initially consisting of nine researchers became a strong and highly technical organization employing some 80 scientists and operating three fully-equipped fire research laboratories and cooperative projects.

Revised for Relevance

Brown has devoted most of the past years to work on revising and updating "Forest Fire Control and Use" to ensure its complete relevance to present-day forest environmental conditions.

Moisture in Living Fuels Affects Fire Behavior

Clive M. Countryman

"Last year at this time, we got our shirttails burned trying to keep the fire within bounds when we burned the block next to this one. Now it won't burn worth a damn. Everything is the same as before —temperature, relative humidity, and wind. Even the fuel stick reads the same. I don't understand it!"

These were the comments of a fire boss in despair as he watched his crew vainly attempt to get a 40-acre prescribed burn going in a stand of southern California chaparral one afternoon in late March 1973.

But everything wasn't the same. Both winter and early spring of 1973 had above normal precipitation, with the rain coming in small, well-spaced storms that kept the amount of moisture in the ground high. The chaparral responded by starting to grow early, and by putting out large amounts of lush new growth with a high moisture content. In contrast, 1972 was deficient in rainfall—so much so that by the spring growing season the first foot of ground had virtually no moisture. The shrubs produced little new growth, some not at all. Thus, the fire boss had overlooked one factor in an otherwise well-planned burn—the moisture content of the living fuel.

Moisture Content Overlooked

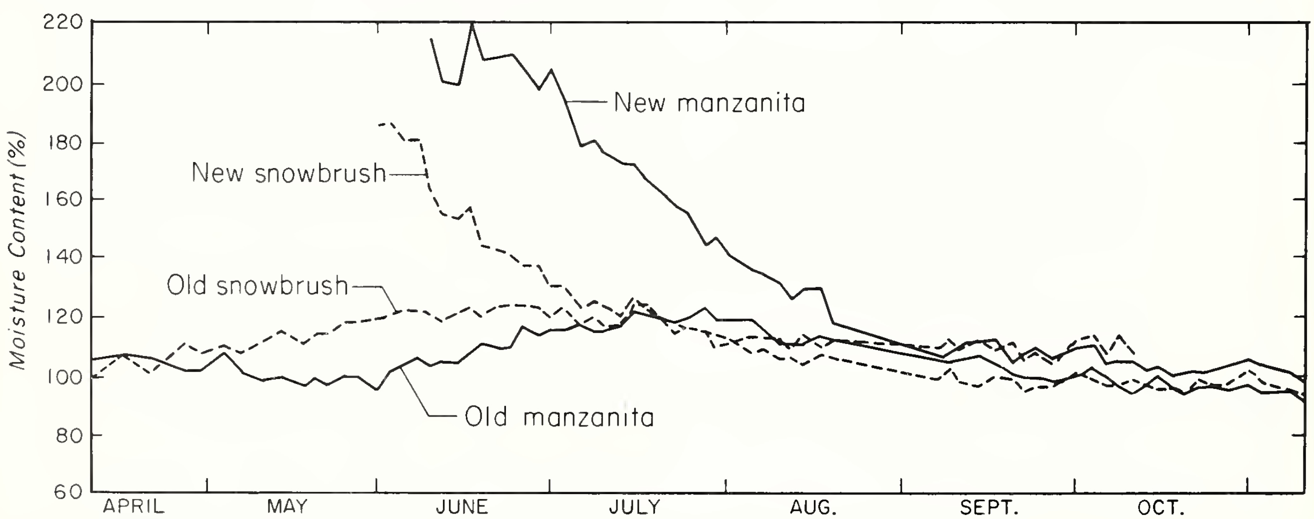
The effects of moisture content in living fuel is often overlooked in the behavior of fire—not only in prescribed burning but in wildland fire control as well. In fuel types where the spread of fire depends largely on crowns, such as in much of the chaparral and brush of the Southwest, the moisture in living fuel is a major factor in the fire behavior produced. It may sometimes determine whether a fire will burn at all.

Usually 65 to 85 percent of the total standing fuel in a mature chaparral stand is living material. Uniformly distributed through this living fuel is dead material. Some species produce little litter, while others may develop a layer of litter and duff of moderate depth, but one that seldom burns rapidly because of its compactness. Some soft chaparral, such as California sage and buckwheat, does neither. When dormant, chaparral stands in which these species predominate can have large amounts of dead fuel and loosely arranged litter. But during the growing season, these species also tend to have the most moisture in the living material.

Although chaparral often appears so dense as to be impenetrable, it contains little fuel compared to the space it occupies. For example, the amount of standing living fuel in a typical 6-foot-tall chamise stand with 25 percent dead material equals a layer of solid fuel less than 1/8-inch thick, and the dead material a layer about 1/32-inch thick. The total volume of fuel is about the same as in a 5-inch-deep layer of ponderosa pine needles.

Because of its high moisture content, living fuel will seldom burn by itself. Heat from burning dead fuel is needed to dry the living material

Figure 1. Moisture contents of manzanita and snowbrush foilage.



to a point where it will burn and add to the heat output of the fire. Since the relatively small amount of dead fuel is distributed throughout the fuel bed, it also does not burn well by itself—the spacing between the dead fuel pieces is too great to produce an intense fire. For a hot fire to develop in chaparral, a large part of the living material must burn along with the dead fuel.

Thus, fire behavior in chaparral depends largely on the amount of dead fuel and moisture content of the living material. When the living fuel is too moist for the available burning dead fuel to dry it quickly, the fire spreads slowly if at all.

Pattern of Moisture Content

The moisture content of living chaparral follows a distinctive pattern during the year (fig. 1). When growth starts in spring, the moisture content of the new material reaches a peak, often near 200 percent of its dry weight, and for some species greater than 300 percent. During this period, the moisture content of the older parts of the shrub increases too, but to a lesser degree than that of the new growth.

As the season progresses and the long, rainless season sets in, the moisture content of the shrub decreases and reaches a minimum when the plants become dormant in fall. The moisture content then remains more or less constant until growth resumes in spring. Low moisture content of the shrubs during winter is one of the chief reasons that areas exposed to periodic dry weather in winter, such as southern California, can have on large chaparral-fires.

The moisture content in living chaparral usually follows the same general pattern each year, but important differences exist from year

Living Fuels, next page

The author is in charge of fire behavior research, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Berkeley, California, stationed at Riverside, California.

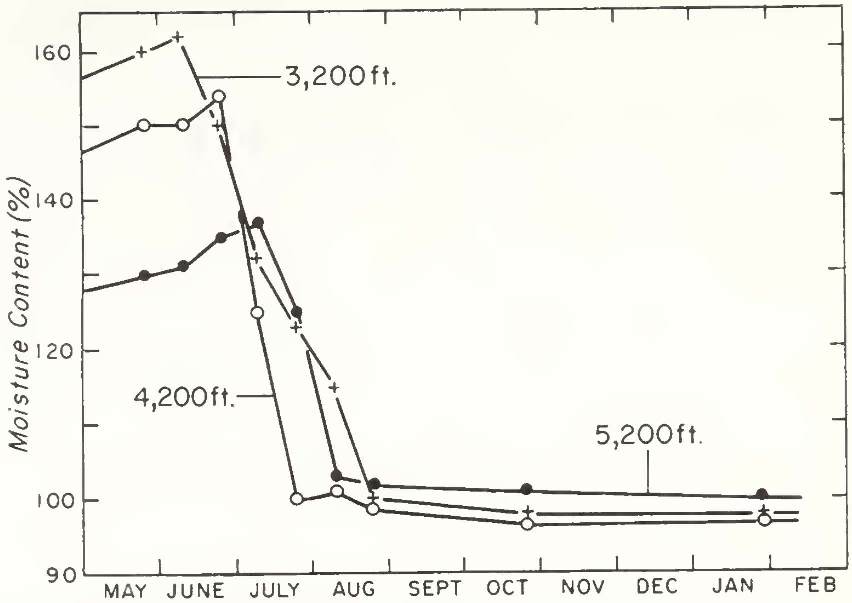


Figure 2. Moisture content of manzanita foilage, by elevation May 1962 - February 1963 (Philpot 1963).

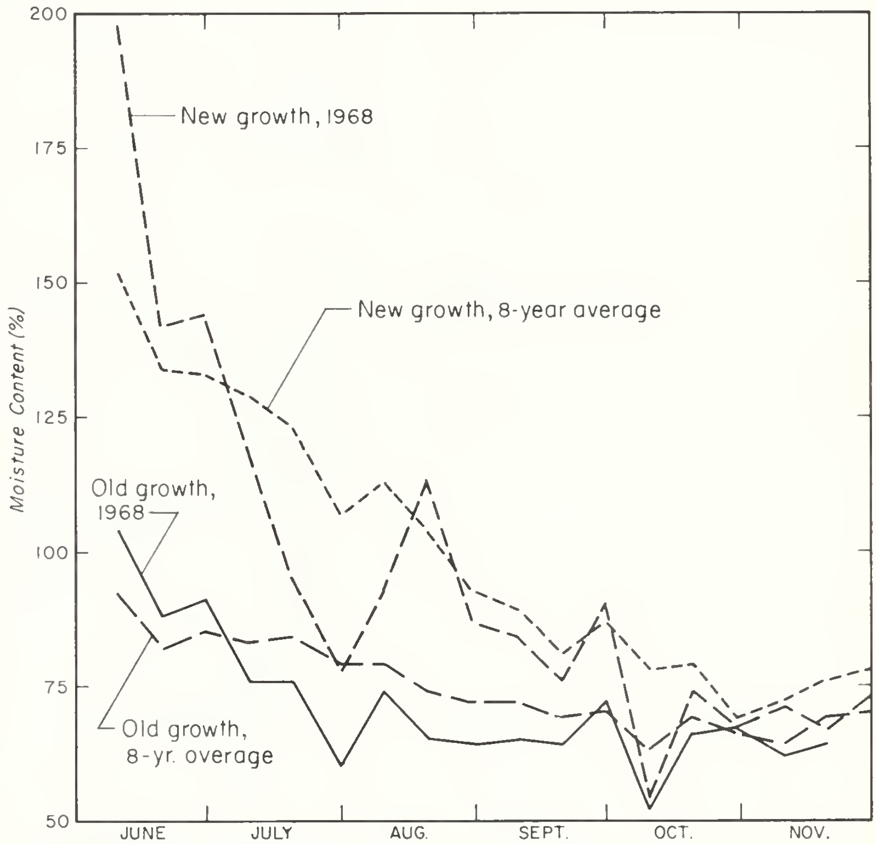


Figure 3. Moisture content of living fuels in chamise, Angeles National Forest, Southern California.

Living Fuels, from p. 11

to year. These differences affect fire behavior and should affect decisions in fire control and prescribed burning.

Changes in moisture content are due to the physiological activity of the shrubs, and this activity is controlled largely by soil moisture and the weather—chiefly temperature. If precipitation is deficient, plants remain dormant or grow slowly.

Their moisture content will increase less in spring than at other seasons when soil moisture is plentiful. If the deficiency presists through summer, the moisture content in living fuel drops quickly.

It will be lower in fall than at other seasons when conditions are normal. Temperature affects the time new plant growth will start. If the weather in late winter and spring is warm, moisture content will increase more quickly than if it is cold, and it will reach a higher level if soil moisture is adequate. Elevation affects temperature; therefore, the altitude at which shrubs are growing markedly affects the amount of fuel moisture and when peak moisture is reached (fig. 2).

Direct Measurement—Best Way

How can land managers determine the moisture content of living fuels when it is so variable? Visual indicators are few—the amount of new growth is about the only readily perceptible one. No analog devices are yet available for estimating living fuel moisture such as the fuel moisture indicator sticks commonly used for dead fuels. Thus, to determine the moisture content of living fuel, we must usually resort to direct measurement.

In California, fire protection agencies collect samples of predominant chaparral species every 10 days from selected areas and send them to the Pacific Southwest Forest and Range Experiment Station's Forest Fire Laboratory for moisture determination. The moisture contents are plotted in graphical form (fig. 3), and graphs are sent to all fire control agencies statewide at 10-day intervals during the fire season, along with other fire danger and weather information.

This procedure has been carried on long enough to permit us to say what the average conditions are for the sample areas and to compare current conditions with the average and with conditions in other years. Only a few areas and species are sampled; hence, the fuel moisture given in the 10-day reports provides only general guidelines for fire control and prescribed burning decisions.

Determining Fuel Moisture

The laboratory procedures used in accurate fuel moisture determination require trained personnel and expensive equipment. However, precise measurement of living-fuel moisture is not needed for general field application, and "do-it-yourself" techniques are quite simple and require little equipment. With reasonable care, adequate and consistent results can be obtained.

One piece of equipment required is a laboratory balance capable of weighing up to 1,000 grams to the nearest 0.1 gram. The beam type balance frequently used in high school chemistry and physics laboratories is adequate and relatively inexpensive. Sample bottles for collecting the fuel samples will be needed; wide-mouth quart Mason jars with screw type caps do very well. Each bottle and cap should be labeled with an identifying number and weight.

The final piece of essential equipment is a drying oven capable of maintaining a temperature of 200° to 205° F. (See microwave oven article, p. 22.) The oven in a kitchen range can be used, but in the interests of domestic tranquility, it is not recommended that the fuel moisture determination be done in the home—some plants produce a strong persistent odor when drying. A better solution is to purchase a drying oven from a laboratory supply house, or have one fabricated in the shop of your organization.

The fuel sampling procedure is also quite simple, but must be carefully followed if consistent and reliable results are to be obtained. To determine the trend of fuel moisture over the fire season, select a sampling area representative of the general area in elevation, aspect, and species. The area should cover 3 to 5 acres, and it should be used each year. Since most moisture variation takes place in the fine material, a good indication of the moisture conditions can be obtained by collecting foilage and small twigs less than 1/8 inch in diameter. Obtain material from all parts of the plant and from as many plants in the sampling area as possible. Remove all dead material from the sample because even a small amount can drastically affect the results. Sample old-growth separately from the new as long as the material can be visually separated, and sample different species separately.

Collect at least two samples of each type of fuel—three samples of each would be better. Each sample should contain 100 to 150 grams of material. This is about the amount that can be loosely packed in a quart jar; it is not necessary to weigh the sample in the field. Cap the sample bottle immediately after taking the sample. Best results are obtained if sampling is done during the same time of day for each sampling period, preferably between noon and 3 p.m. Do not collect samples when the foilage is wet from rain or dew.

At headquarters, weigh each sample, (still capped) to the nearest 0.1 gram and record the weight. Then uncap the samples and place them in the drying oven set at a temperature of 200° to 205° F. Usually a 24-hour drying period is sufficient, although material with a very high moisture may require a longer time. Weigh the samples after 20 hours and again after 24 hours. Don't forget to add the caps when weighing. If the weight change in the 4-hour period is less than 0.2

Living Fuels, p. 13

Smokejumpers in desent.

Living Fuels, from p. 12

gram, the samples are sufficiently dry. But if the weight change is greater than 0.2 gram, the drying should be continued until the weight change in a 4-hour period is 0.2 gram or less.

The sample moisture content in percent is determined from the equation:

$$\text{Moisture Content} = \frac{\text{Wet Weight-Dry Weight}}{\text{Dry Weight}} \times 100$$

To find the wet weight of the sample, subtract the weight of the sample bottle from the weight of the sample and bottle that was obtained when the sample was brought to headquarters. The dry sample weight is the weight of the bottle subtracted from the sample and bottle weight at the end of the drying period.

Living Fuels, p. 14

Smoke Jumping . . .
An Expanding, Varied Role

William D. Moody

Since 1940 smoke jumpers have been an important part of the fire suppression team. The smokejumper, through his versatility, equipment improvements, and progressive management, continues to play an important but changing role in forest fire suppression.

An Important Role

The overall area covered by smokejumpers and the number of fire jumps has increased. Growing from a squad of 14 men in 1940, today's force of over 400 jumpers has made as many as 4,500 fire jumps to 1,200 fires a single year. Once restricted to use in the inaccessible mountainous areas of the Pacific Northwest and Intermountain Region, today's highly mobile aerial fire fighters combat fires in the Alaskan interior, the entire Western United States and, since 1971, in the Southern Region, Forest Service.

Forest Service smokejumpers give assistance to State and other Federal agencies upon request.

Smokejumpers' New Role

Originally conceived as a force to combat small backcountry fires, smokejumpers now have an expanded role. Smokejumpers help meet today's fire control objectives, whether it be to reinforce helitack or other initial attack forces or to perform as an organized suppression crew on project fires—in heavily roaded or accessible areas. Their specialized training with chainsaws and one-man mechanical fireline trenchers enables smokejumpers to serve as line cutting, snag felling, or mechanical fireline construction crews. On project fires, they jump to spot fires and reinforce ground crews when hot spots flare up along the main fire perimeter. Crews of jumpers are dropped at selected points on the fire perimeter to construct helispots and heliports.

In addition to fire suppression, jumpers had other roles. With an ever increasing recreation use of back-country areas, smokejumpers are used for emergency para-rescue missions. Parachuting project crews perform a variety of jobs such as telephone line maintenance or removal, helispot construction, timber inventory, and trail maintenance.

Better Equipment

To meet the needs of the 1970's equipment continues to be improved to do the job better, faster and safer. Jumpers today are attired in fireproof Nomex jump suits and the latest in head protection gear.

Maneuverable parachutes enable jumpers to jump safely under adverse conditions in rugged mountainous terrain.

Improved Aircraft

The most important advancement in smokejumping is the aircraft used to carry out the smokejumper mission. Modern, fast aircraft help meet initial attack objectives. A modern, fast, turbine powered aircraft used during 1972 season reduced smokejumper manning time by 50 percent. Aircraft capable of 270 to + 300 mi/h will replace the 165 mi/h Twin Beeches and DC-3's used for many years.

Infrared fire spotting equipment mounted on jumper aircraft help the smokejumper spotter locate fires

Smoke Jumping, next page

Smoke Jumping, from p. 13

difficult to detect visually. Once on the ground, jumpers use chainsaws, mechanical fireline trenchers, and other modern fire suppression equipment. As soon as the fire is out or the jumpers are released, helicopters are often used to retrieve the jumpers and quickly return them to their base for another fire call.

Automatic Dispatch System

Speed of initial attack is a paramount fire control objective. Progressive fire managers have taken steps to speed manning of fires. In the Pacific Northwest Region, two smokejumper bases operate on an automatic dispatch system. The smokejumper base dispatcher, upon monitoring an emergency fire call, automatically dispatches jumpers to the fire. Used for 6 years on the Okanogan National Forest in North Central Washington, this system has been a significant factor in meeting critical initial attack manning objectives and reducing fire losses.

Smokejumpers on Patrol

When lightning storms are in progress, smokejumper aircraft patrol behind the storm and man fires as soon as they are detected. Routine smokejumper patrols have also proven valuable in areas of lightning "sleepers" and high man-caused risk. On an experimental basis, small smokejumper aircraft, with two or four jumpers aboard, have replaced single engine aerial detection aircraft on routine daily patrols. Once limited to operating from large permanent bases, jumper crews in some regions now operate from satellite bases located in or adjacent to areas of high risk or extreme fire danger. Often these satellite bases are manned on a daily basis with the crew returning to the home base each night.

It is apparent to foresters who have used automatic dispatch, jumper patrols and decentalization of smokejumper forces that they are much better able to meet their initial attack objectives through these management practices.

The Future

The smokejumper program can continue to play an important role in meeting fire attack objectives. The future of smokejumping depends upon how fire managers will use this resource. Through utilization of their versatile skills, continued technological advancement, and progressive management practices smokejumpers will continue to be an integral part of the fire suppression team in the 1970's.

William D. Moody is a smokejumper base manager, North Cascades Smokejumper Base, Okanogan National Forest, Pacific Northwest Region, USDA - Forest Service.

Living Fuels, from p. 13

For example, suppose the sample bottle weighs 393.8 grams. When the bottle is filled with the fresh sample it weighs 494.8 grams, and after the drying period, 448.9 grams. The wet sample weight will be 494.8 −393.8 = 101.0 grams. The dry sample weight is 448.9 −393.8 = 55.1 grams. The moisture content of the samples is $\frac{101.0 - 55.1}{55.1} \times 100 - 83.3$ percent. Duplicate samples of the same material should be averaged.

Measurement for Prescribed Burning

To obtain measurements of living-fuel moisture for use in prescribed burning, follow the same basic procedures, but collect the samples in the area of particular interest. If the burn area is large, covers a wide range in elevation, or is on more than one aspect, more than one sampling area with separate samples will be needed for a good evaluation of living fuel moisture conditions. Since living-fuel moisture changes slowly, the sampling may be done several days before the planned date of the burn, thus providing information that can be useful in deciding whether to burn or not. By relating living fuel moisture to fire intensity and burn effectiveness over a period of time, a backlog of information can be built up that will help in planning prescribed burns.

Most experimental work and practical application of data in living fuel moisture to fire control and fire use activities has been in chaparral and brush fuels. But other fuel types also have moisture variations that can significantly affect fire behavior, although the moisture patterns may be different than for chaparral. For example, the moisture content of the needles of some conifers varies enough during the fire season to affect the potential for crown fires. By sampling living fuels at regular intervals, the moisture patterns and current conditions can be established. This information can help the fire boss in his decisions about fire control and fire use.

Reference: Philpot, C. W. 1963. The moisture content of ponderosa and whiteleaf manzanita foilage in the central Sierra Nevada. U.S. Forest Serv. Res. Note PSW-39 Pacific Southwest Forest and Range Experiment Station, Berkely, Calif. 7 p.

Electronic Fire Marker Being Tested in Canada

Fires producing little or intermittent smoke are frequently spotted and reported from patrol aircraft, but they cannot be readily relocated by initial attack crews travelling on the ground or via helicopter.

To assist relocation from both ground and air, an electronic fire marker has been developed at the Northern Forest Research Center in Edmonton, Alberta. It will be used operationally in Alberta during the 1974 fire season. Other provinces are currently evaluating the system.

The transmitter was designed and built to the receiving specifications of the common fireline radio. It operates on the frequency 26.920 MHz and is activated by installing a 9-volt

transister radio battery, just prior to airdropping. Cost per transmitter is about $75; however, they are retrievable and can be used numerous times.

Detection of the transmitter is achieved by modifying an ordinary fireline radio for use as a direction finder (approximate cost: $20). Function of the radio as a transceiver for ground-to-ground communications is not impaired. The transmitter is identified through the receiver by production of an audible pulsed signal. Signal strength intensity increases as the receiver is moved in the direction of the transmitter. Effective range is 2 to 5 miles on the ground and 10 to 20 miles from the air.

A modified fireline radio connected by a coaxial cable to a tuned whip antenna mounted on the landing gear of a helicopter, is used to locate fire from the air. The same receiver but with a loop antenna is used to direct ground crews to the fire. Field tests indicate this system will satisfy the need for a reliable fire marker.

This system is described in detail in Northern Forest Research Center Information Report NOR-X-61. Canadian Forestry Service, 5320-122 Street, Edmonton, Alberta, T6H 3S5.

Hand Grenades Needed For Control Burns

Inexpensive, safe, hand thrown incendiary grenades are needed for ignition on control burns and wildfires. Present methods such as trip torches, propane torches, and fuses can accomplish the task. Fuel blocks and rigid foam grenades show promise for being effective.

Several types of grenades were tested by the USDA Forest Service Equipment Development Center, Missoula, Mont., to determine how well they met test criteria of:

Safety. Should be safe for use by untrained personnel, which eliminates explosive dispersal charges.

Burning Characteristics. Flame agent should not burn in one concentrated spot, and should burn for at least 1 minute.

Container. Should be completely consumed by the fire, should have a long storage life, and should withstand rough handling.

Weight and configuration. Should have the right weight and shape for throwing (about 8 ounces of flame agent).

Igniter. Should be attached to the grenade just prior to use, and should not use a burster charge.

Grenades can be conveniently broken down into three components: initiators, flame agents, and containers.

Initiator

The simplest initiator found was the friction-type head on the fusee. Another was igniter cord, which is an outward burning fuse capable of igniting readily combustible material which it contacts. It can either be wrapped around a combustible fuel container or can contact the fuel directly. The cord can be ignited with a match or a pull wire igniter.

Blasting safety fuse can be used to ignite a priming compound which in turn ignites the fuel. Black powder, thermate mixture, etc. can be used as priming compounds. Safety fuse can be ignited with a match or pull wire igniter.

The initiator can also be made to act as a disperser by adding a small explosive charge to the priming compound, and the areas of coverage can be regulated by varying the size of the dispersal charge. This type of initiator must incorporate a time delay to prevent injury to personnel. A length of safety fuse can be used as a delay, but very short lengths should not be used since burning rates can vary considerably. Potent dispersal charges are potentially dangerous, especially when used by untrained personnel.

More sophisticated, reliable and expensive initiators are feasible, such as those used in military grenades. These consist basically of a striker fired primer, which ignites a powder train, which, after a delay, actuates an ignitor/disperser.

Flame Agents

The two basic types of flame agents tested were viscous liquids or gels and solids. The gels were all thickened hydrocarbons, such as gasoline thickened with special soap, or proprietary thickened diesel. Their long burning time and ability to flow and adhere to the fuel are advantages when igniting heavy damp fuels.

Grenades, p. 17

2-agency Group Completes Planning in Record Time

Robert L. Irwin and

Donald G. Halsey

The enormous toll exacted by wildfire makes interagency cooperation imperative. Thus, cooperative agreements for mutual assistance between firefighting agencies exist nationwide.

However, it is unusual for one agency to convene an interagency group to attack a single-agency problem and have the plans completed in 30 days.

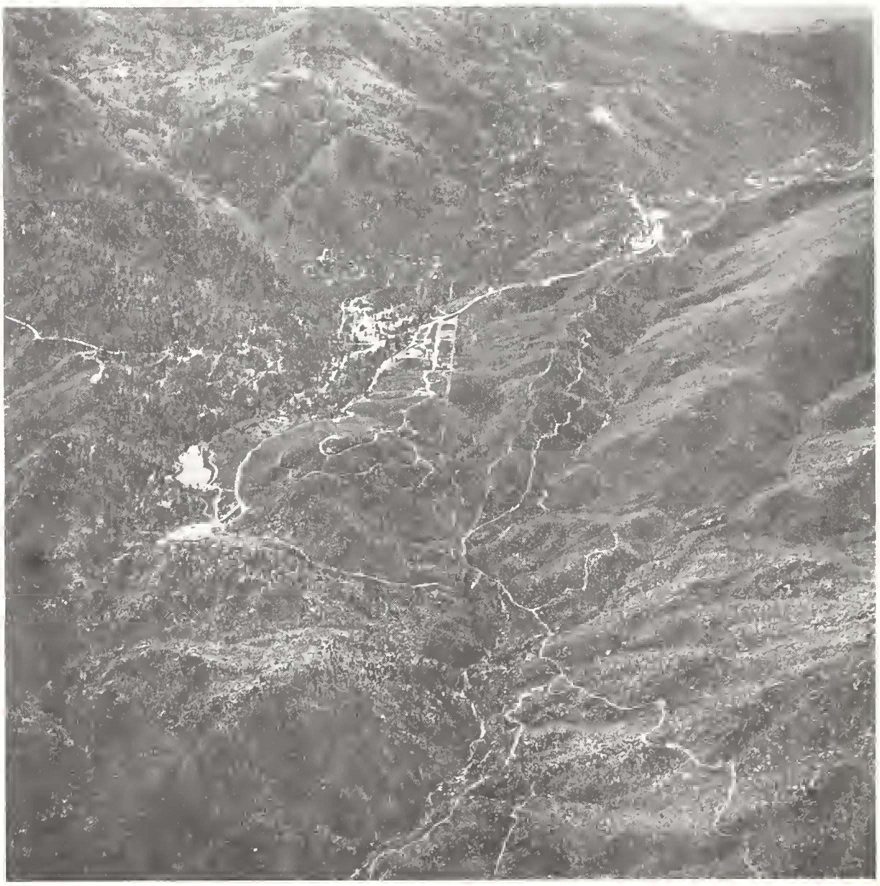
Working under emergency conditions, the Bureau of Land Management (BLM), U.S. Department of Interior, convened with the USDA Forest Service to develop such a plan for the Hualapai Mountain (pronounced ''wall-a-pie'') area, south of Kingman, Ariz. The range covers some 600,000 acres and extends southeasterly nearly 45 miles. A wide variety of vegetation covers the range. Shrub types in the lower elevation give way to mixed brush species and finally coniferous types at 6,000 feet and higher.

The Problem

At the northern end of the mountains three parcels of private land have been subdivided. More than 150 homes have been built; another 300 are probable in the future. Year by year the high country attracts more and more visitors from Kingman and the Colorado River, only a short drive from the mountains. On hot days, the recreationists move to the upper elevations to cool off. Mohave County, Arizona, owns and maintains a park and recreation area near the subdivisions.

Sixty percent of the land in the Hualapais is administered by the BLM. Most of the remaining, intermingled, lands are private ownerships in Arizona.

The BLM has long recognized the fire potential in the Hualapais. In 1961, a 1,600-acre fire cost $1 million to suppress. More recently, a number of 200- and 300-acre fires have occurred. However, lack of funds and higher priorities elsewhere forced the BLM to limit its fire control and fire management activities.



Aerial view showing extensive area of fuels surrounding community of Pine Flat in Hualapai mountains. To protect the community from fire, the following fuel modification treatments were proposed: crush and burn; hand-cut 60 percent of vegetation and burn; buck, pile, and burn snags, dead and down material, prune trees, create 300-foot wide shaded fuel brakes; prescribed burning later if needed. Selection of fuel treatment depends on location, fuel type, and extent of fuelbreak needed.

Robert L. Irwin is Research Liaison Forester, Pacific Southwest Forest and Range Experiment Station, Forest Service, USDA, Berkeley, Calif., stationed at Riverside, Calif. Donald G. Halsey is Chief, Division of Standards and Training, Boise Interagency Fire Center, Bureau of Land Management, USDI, Boise, Idaho.

Then, the 1972-73 winter brought extraordinary rainfall, and the mountain's vegetation responded with unusual growth. Grasses covered areas that had been barren for years. Brush species sprouted vigorously. These added fuels, coupled with increasing public use and the expectation of a severe fire season, escalated the Hualapai problem in the BLM's management priorities, and special actions were started to take care of the situation.

First, the BLM moved a team in from the Boise Interagency Fire Center to train local manpower in fire suppression. A Bell 205A helicopter and a B-17 fire retardant aircraft were obtained by special contracts and stationed at the Kingman airport. A portable, emergency retardant base was developed there to support these aircraft.

The Planning Team

While the suppression forces (including an 8-man helitack crew) were being developed, the BLM called for a second team to prepare a fire protection plan. Donald G. Halsey of the BLM and Robert L. Irwin of the Forest Service formed the nucleus of this team, at Kingman on May 23, 1973. A varying number of other BLM personnel, and another member of the Forest Service, Edwin W. Masonheimer, served on the team during June to provide field data and fire prevention information for the plan. The team was to complete the plan by July 1, 1973.

Much of the data needed to prepare a comprehensive plan were not available in existing records. Limited information on weather fire occurrence, and fire behavior was augmented by extensive ground and aerial reconnaissance. Interviews were conducted with knowledgeable local people to confirm necessary facts.

The Hualapais resemble many National Forest areas in Arizona and southern California. To compensate for gaps in available records, the planning team turned to Forest Service research and that agency's National Fire Planning guides.

Planning Procedure

Using Forest Service pre-attack guidelines, Halsey's BLM assistants covered more than 100 miles of roads and 50 miles of ridges. They scouted and mapped locations for hand and bulldozer firelines, water sources, fire camp sites and safety zones.

No detection plan for the Hualapais existed. Although aerial patrol was often performed after lightning storms, any action taken was not systematic. Therefore, a new detection plan was designed. No structures were proposed, but a number of higher peaks were designated as having the best seen areas. A system of manning these points according to fire weather was developed. This was integrated with a recommended systematic aerial detection plan. Methods of utilizing locals, state highway patrolmen, county employees, and even local private pilots to supplement BLM detection efforts were outlined in the plan.

Information on rates of fire spread for similar fuel types on the Prescott National Forest, 60 miles away, became the basis for the suppression phase of the plan. These figures, developed by Lindenmuth and Davis[1] for prescribed burning, provided a starting point for calculating expected suppression workloads under varying conditions of fire weather.

The Pacific Southwest Forest and Range Experiment Station is developing a computerized simulation

Planning, p. 22

[1] Lindenmuth, A. W. Jr., and James R. Davis. 1973. Predicting fire spread in Arizona's oak chaparral. USDA Forest Serv. Res. Pap. RM-101, 11 p. Rocky Mt. Forest and Range Exp. Stn., Fort Collins, Colo.

Grenades, from p. 15

One type of solid flame agent is fusee material, which is a mixture of wax and sawdust, and has a burning temperature of about 1,400° F. Since the flame agent is solid and flame lengths are short, placement of the grenade in the fuel bed is critical.

The thermate material used in military incendiary grenade is a mixture of incendiary materials, and a starter mixture. This material burns abour 4,000° F. and leaves a residual puddle of molten iron.

A mixture of 50 percent powdered aluminum and 50 percent calcium sulfate (plaster of paris), when cast into shapes with suitable orifices and properly ignited, burns at about 3,000° F. and shoots jets of molten aluminum out of the orifices for distances up to 6 feet, and leaves a puddle of molten aluminum.

Another solid fuel consisted of rigid foam impregnated with petroleum fuel. This fuel ignites with igniter cord or a match, and burns at about 1,500° F. with varying flame lengths up to 18 inches.

Container

Three basic types of containers were encountered during the tests: metal, paper and plastic. Metal containers are durable, but leave undesirable residue after use, and contribute to shrapnel hazards if a dispersal charge is used.

Paper containers are adequate for solid fuels, and can be used for liquids if a plastic inner liner is employed. They do not leave a permanent residue after use.

Plastic in either film, solid or foam form can be used for containers that burn completely. Polystyrene foam burns readily, but is dissolved by hydrocarbons. Some plastic films such as polyethlene are permeable by hydrocarbon liquid or vapors.

None of grenades tested met all of the requirements set up for a hand thrown grenade, however, fuel blocks and rigid foam grenades show promise.

A Vital Concern . . .

Fuel Treatment and Aircraft Equipment Needs

Russell P. McRorey

Fuel treatment and aircraft-use programs are of vital concern to fire managers today. What we do about fuels affects nearly every facet of fire management, and air operations interplay with nearly all facets of fire management. It is, therefore, appropriate to look at present-day and future equipment needs of these two programs.

Let's examine fuel treatment equipment needs first. To do so, we need to select an objective which will guide our development efforts in the years ahead. An objective which appeals to me is "To develop, test, and evaluate equipment which will reduce accumulations of forest residues and natural fuels, and thus upgrade the forest environment and its productivity."

Obviously, achieving this objective involves more than just equipment development. It requires better utilization of logging residues; greater use of prescribed burning, particularly in natural fuels; and the development of additional wood products which utilize residues. Present-day equipment development in the fuel management field complements and supports these programs. We need also to consider parameters affecting the selection of equipment development projects in managing fuels:

- Land use and environmental goals
- Type and volume of fuels
- Air quality constraints
- Protection values
- Current backlog of untreated fuels
- Available work force
- Cost effectiveness

You can probably think of others, depending on the needs and policies of your organization. One thing we can say is that none of these parameters are static; rather, they are dynamic, controlling forces in equipment development.

Recognizing the influence of the sideboards, let's look at existing hardware, and some that will be tested and put into operational use in a couple of years.

Firing Equipment

- Grenades
- Helicopter grenade dispensing equipment
- Slip-on pumper flame thrower
- Hand-held torches and flame throwers

Line Holding Equipment

- High volume retardant sprayer slip-on unit
- Slip-on retardant mixer-sprayer

Fuelbreak Construction and Maintenance

- Thermal brush burner
- Explosives for fireline building

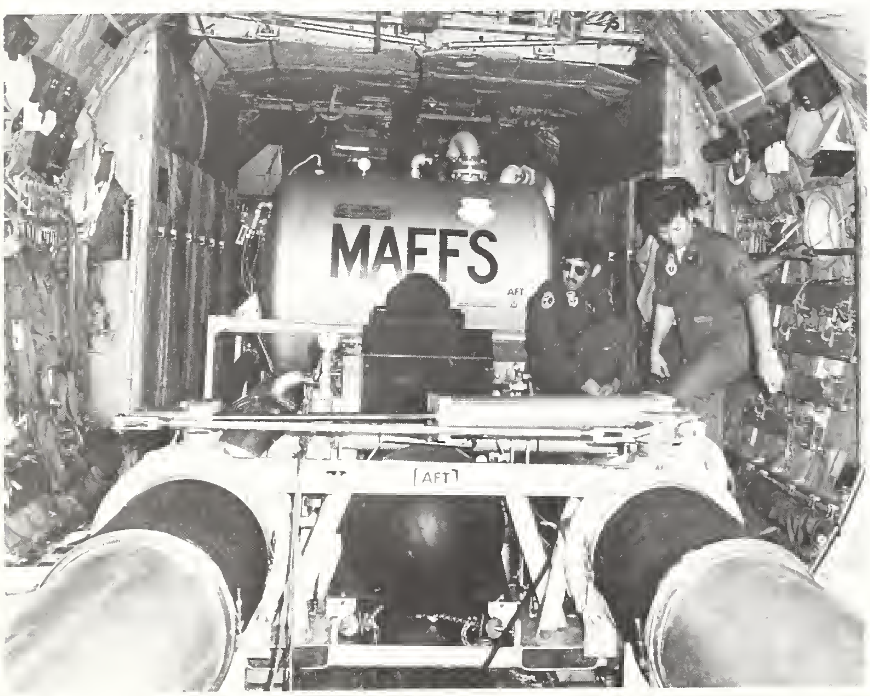
Fuel Utilization Equipment

- Portable debarkers
- Portable chippers and flakers

Fuel Reduction

- Rollers
- Choppers
- Incinerators
- Air curtain destructors
- Tree eaters
- Rotory plow
- Lucky Loggers
- Hydro axe
- Tomahawk crusher

MAFFS (Modular Airborne Fire Fighting System). A USAF-USDA Forest Service cooperative system ready for use by the USAF as a backup to contract air tankers during disaster situations.



You will recognize that much of this equipment is in existence and in use. However, items such as slip-on flame and hi-volume retardant units, fireline explosives, and thermal brush burners are still in the proposal or test stage.

Fuel Treatment Equipment —Future Needs

As we make the transition from today's fuel treatment equipment to future needs, we see little change in program goals, except for a stronger thrust in the treatment of natural fuels and a greater use of logging residues. Changes that emphasize natural fuel treatment are directed toward the goal of "lowering the flammability of the forest."

Most fire managers agree that occurrence of large fires represents a failure somewhere. This failure often can be traced to soft spots in prevention, detection, initial attack, the suppression action, or lack of fuel management.

Lowering the flammability of the forest not only requires attention to man-created fuels, but also treatment of natural fuels. Until such time as we make significant inroads in fuel treatment, we will continually have to cope with an increasing number of large fires.

This brings us to the need for a penetrating examination of future fuel management equipment needs. As a basic tenant, we first must accept that better utilization of man-created residues is essential. If better use of these residues can be achieved the role of mechanical equipment in fuel treatment can be diminished in proportion to the volume of non-recoverable residual fuels generated.

If we accept the basic tenant of "better utilization," then we should strive to:

- Improve existing mechanical fuel treatment equipment to provide lower operating costs.
- Improve aerial dispersal of incendiary devices to exploit use of prescribed fire.
- Develop chemical burn promoters and extenders to enhance the burning operations.

While chemical burn promoters and extenders are not equipment in the strict sense of the word, they are closely allied with, and will be dependent on, equipment for dispersal. Of all the items mentioned, I see chemicals as a real breakthrough in future fuel management programs.

With chemicals we can extend periods of prescribed burning to minimize losses. From this we can capitalize on the use of fire as an inexpensive fuel treatment method, Yet minimize air pollution by having greater flexibility in selecting low, airpollution weather conditions.

These are my assessments of equipment needs, present and future, in fuel management programs. There is no question that equipment development has a vital role to play in fuels management. It seems a safe bet that equipment development will undergo expansion because we cannot sweep the fuels problem under the rug. Our challenge as fire managers will be to specify our needs in such terms that development engineers can translate them into cost effective hardware to meet program needs.

Aircraft Equipment Needed Now

Like fuel treatment, air operations has unique requirements in the equipment field. In fact, over the years equipment developers have been hard put to keep pace with expanding technology and changes in aircraft performance. This time lag has penalized the user because he is unable to profit from advanced aerial delivery systems.

Fuel Treatment, next page

Fuel modification to reduce fire hazard and upgrade the forest environment.

Before we explore todays aircraft equipment needs, let's consider them in the context of protection organization objectives for aircraft operations. Stated in its simplest terms the objectives of air operations is to "aid in the safe, efficient and economical protection and management of forest lands." Using this as a guide we would expect today's aircraft equipment to enhance and maximize our ability to benefit in the rapid tactical and logistical support afforded by aircraft.

Today we find ourselves concerned with the need for effective, hardhitting initial attack, followed by rapid mobilization (and demobilization) to obtain control of fires not responding to initial attack. All this must be accomplished in the face of increased hazard and risk brought about by an accumulation of mancreated and natural fuels and an ever increasing use of forest and range lands. Tactical employment of aircraft, particularly on initial attack, improves our firefighting capability.

Future aircraft equipment needs will focus on suppression related activities. This does not discount other land management program needs for aircraft equipment, but these needs have received less emphasis because they are mostly non-emergency in nature.

Today's aircraft equipment development efforts have been focused primarily on delivery systems, ranging from retardant through air cargo to smokejumper operations. The following list, while not all-inclusive, gives us an idea of what's being done in aircraft equipment development and sets the pattern to today's needs:

Retardant

- Chemical mixing and handling equipment.
- Tank and gate designs
- Helicopter bucket design
- Ground personnel warning devices
- Airtanker evaluation and qualification
- Modular tank systems for fixed wing and rotor aircraft

Infrared

- Air-to-ground telemetry
- Bi-spectral imagery

Helicopters

- Standardization of light accessories
- Nightflying
- Firefighter rappelling

Air-Ground Delivery Systems

- Radio controlled cargo chutes
- Smokejumper aircraft modernization

Developing products such as illustrated here for low quality forest residues is a key to fuel modification reduction program.

Speed and Accuracy

Two areas which have received too little attention are speed and accuracy in retardant dropping. With the waning days of vintage reciprocal powered aircraft and the transition to pure jets in commercial and military aviation we cannot continue to rely on fixed wing aircraft for retardant dropping. Future delivery systems should accommodate dropping at higher speeds and higher altitudes.

Where does accuracy fit into this picture? Well, it is quite obvious if we increase drop speeds and altitude, accuracy will become more critical. Equipment developers need to consider bomb sights and ground beacon electronic devices to accommodate retardant aircraft flying at high altitude and high speeds. In fact such devices could be put to good use today.

More and more we are going to take advantage of night-time operations in combating large fires. I have already mentioned night helicopter flying using special goggles and forward looking infrared. These exciting developments are just a precursor to a whole array of equipment needs to support night fireline operations.

I would like to suggest the following as a future aircraft equipment development list:

- Ballons for night lighting and fireline cargo delivery
- Helicopter hardware for smokejumper operations
- Fixed-wing and helicopter light accessory hardware for support of advanced air-to-ground delivery system
- Low-cost air-to-ground telemetry gear for infrared imagery transmission

Fuel Treatment, next page

From a speech by Russell P. McRorey, Associate Deputy Chief, Forest Service, USDA, at the 1973 Southwest Fire Council Meeting, Phoenix, Arizona, November 29-30, 1973.

Night-vision Copters Proposed To Improve Forest Fire Fighting

Herbert J. Shields

Spy-in-the-dark helicopters could double the effectiveness of firefighters as they battle fires in the forests and wildlands according to a report made recently to the Watershed Fire Council of Southern California.

Navigational aids that will permit helicopter pilots to "see" at night could increase firefighting effectiveness in the wildlands from 25 to 50 percent.

When fire hits in the wildlands of southern California, the attack is often hampered because 25 to 50 percent of the crew is set down at night—aircraft cannot be used safely and effectively. Dozers, tankers, and other heavy equipment cannot be moved into strategic positions over dark and treacherous terrain.

Night Best to Fight

Paradoxically, however, night is the best time to hit a fire—cooler temperatures, higher humidity, slackening winds, and more stable air give firefighters an edge over the more turbulent conditions in daytime. All they need is the ability to see and to direct their activities safely and effectively.

To provide that night vision, forest-fire specialists and land managers from civilian resource agencies have begun an evaluation program to see if military techniques used in nighttime helicopter flights can be effective in fire suppression.

For Program Information *Contact Herbert J. Shields, Equipment Development Specialist, San Dimas Equipment Development Center, 444 E. Bonita Avenue, San Dimas, Calif. 91773.*

Sponsored by the Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif., the program involves the active participation of the National Forests of California, the Los Angeles County Fire Department, the Bureau of Land Management, and the Night Vision Laboratory, Sacramento Army Depot.

Helicopters on loan from the Department of the Army have been equipped with forward-looking infrared scanners that transmit reflected radiant energy to two videoscopes in the cockpit which then produce daylight pictures of the terrain ahead. A second system under test involves night vision

Night-Vision, next page

Night Vision goggles amplify starlight or moonlight and display pictures of terrain on a miniature viewing screen.

Fuel Treatment

- Airborne retardant mixing units for waterscoop equipped aircraft
- Bomb sight and electronic homing devices for accurately targeting retardant drops
- Homing beacons for aerial delivery systems

In summing up future aircraft equipment needs, I would like to reinforce the obvious fact that the helicopter will become our most important working platform of the future. We have all seen its evolution as a work-horse in fire operations. But I see this as a mere threshold to what lies ahead when the helicopter becomes our principle airborne support for virtually all movement of manpower, equipment, supplies and retardant dropping. As fire managers, let us be ready with our equipment needs.

Night-Vision, from p. 21

goggles—completely self-contained electronic instruments, similar to binoculars, that amplify starlight or moonlight and display pictures of terrain on a miniature viewing screen.

Both systems are under test in Marana, Arizona, where pilots from Los Angeles County, the Bureau of Land Management, and the Forest Service are training for this specialized flying.

Helicopters are, of course, frequently flown at night in commercial and private transportation, but these flights are made with well-established flight plans, over navigational aids, well-lit sites, and other reference marks.

Pilots Must Pinpoint Position

When using helicopters over the rugged terrain and under the rapidly changing conditions associated with forest fires, pilots must be able to pinpoint their position in relation to ground topography, often over unknown and hazardous areas.

If the tests and training programs are successful, the Forest Service and the other agencies involved will plan for a network of helicopters equipped with night-vision systems at strategic fire locations throughout southern California.

Once the network is established, pilots will be ready to provide the eyes in the night that firefighters need to get wildland fires under control before they become major conflagrations, with resulting loss of life and property.

Microwave Oven Dries Fuels Fast

Thomas Y. Palmer and George D. Pace

Because moisture affects the flammability of wildland fuels and rate of fire-spread, quick, efficient, and reliable methods of determining water content of fuels are urgently needed in firefighting and fire research. Drying fuels by microwave oven may be the answer.

Water is held in wood in a variety of ways: By capillary condensation in the wood cell walls or in the microscopically visible capillary structure, by the hydrogen bonds of cellulose, or by the structure of the cellulose molecule.

During the drying of a piece of wood, the water moves through it to the air in a complicated manner. A single molecule of water may be held briefly by just one or perhaps all of the ways just before it finally evaporates. The end point at which sorbed water is removed by drying is nebulous; therefore, the dry weight of cellulose is not a precise, definable quantity. It is an expression used arbitrarily to describe the result of a particular drying method or process.

Less Time with Distillation

Buck and Hughes (1939) compared various laboratory methods for determining moisture content of cellulose, including distillation drying ovens, vacuum ovens, and dry air. They concluded that the xylene distillation process was usually chosen becuase it takes less time (1 hour) than the drying oven (48 hours), vacuum oven (24 hours), and dry air process (14 days). They found little variation among results from these methods.

The xylene distillation method has become standard in the Forest Service for determining fuel mois-

Microwave, next page

Planning, from p. 17

model called FOCUS (Fire Operational Characteristics Using Simulation) to predict probable results of various fire planning alternatives. The planning team gave FOCUS its first real-world application by using it to evaluate two alternative dispatching schemes.

A fire prevention inventory and analysis provided a clear profile of the threat to the subdivided areas. The format for an intensive prevention program resulted. The lack of State and local laws and ordinances needed to set standards and provide enforcement tools was noted. Mohave County promised cooperation to remedy this deficiency.

It was necessary to develop two sections of the plan specifically for the communities at the northern end of the mountains. These sections concentrated on public safety and community protection, and were based on previous work done by Irwin in California's central Sierra Nevada. The public safety section required an organization which included local fire departments, the Arizona Office of Emergency Services, the Mohave County Sheriff's Office, Search and Rescue Team, and Road Department. Fuel modification methods were recommended (see photo) to achieve a system of fuelbreaks and reduced fuel zones around each subdivision.

The final portion of the plan suggested ways to use the large reservoir of volunteers available to help implement the total proposal. Church, civic, and school groups, retirees, news media, and organized clubs were included.

Unique Aspects

The inclusion of the Forest Service in the planning was especially significant because none of its activities were connected with the lands involved. Local agency (Mohave County) participation increased the magnitude of the cooperative effort.

Basic research, applied research, organizational planning processes, and practical field experience were combined in a "crash program" that produced results. All phases of fire management were integrated into a single package ready for implementation at the field level.

The cooperative planning approach used and the lessons learned on the Hualapais can be applied to good advantage in many other areas of the United States.

Canadian Delegation Reviews USSR Forest Fire Control

Peter Kourtz

Russian placing hose type explosive (1 kg/meter) in 8″ trench in preparation to blasting a fire line.

The Canadian Forestry Service, Department of the Environment, sponsored a two week, four-man (plus interpreter) delegation to tour the USSR forest fire control facilities during August and September, 1973.* The trip was the second of a continuing exchange of visits and was in specific response to the USSR's October 1972 fire delegation visit to Canada.

Purpose of this recent visit was to obtain detailed information on their fire control operations, including specifics on organizational structure, helicopter initial attack system, communications system, fire line construction equipment, techniques such as use of explosives for fire suppression, fire prevention, and forest fire research. The initial Canadian visit to the USSR (1967) studied their general forestry operations, but few specific details regarding methods of fire control were obtained.

The delegation consisted of W.G. Cleaveley, Director, Field Services Division, Ministry of Natural Resources, Ontario; M. Vezina, Assistant Deputy Minister, Department of Lands and Forests, Quebec; S.M. Petrusewicz, Vice President, Wajax Manufacturing Ltd.; P.H. Kourtz, Researcher, Forest Fire Research Institute, Canadian Forestry Service, Department of the Environment; and W.D. Pierce, Interpreter, Secretary of State.

USSR, next page

---

* Excerpted from Miscellaneous Report FF-Y-2, Forest Fire Research Institute, Ottawa, Ontario.

Resulting 15′ wide line from deterioration of hose type explosive. Note the long handled shovel in background.

Microwave, from p. 22

ture content. Although this laboratory technique is faster than other methods, it has limitations, some subtle toxicity, and the hazard of fire and explosion. Furthermore, it is not suitable to field use because the glassware is fragile.

Microwave Oven Drying

Liquid water in cellulosic materials absorbs microwave energy because of the interaction between the water molecules, electric dipole, and microwave electric field. Water held in the wood by the hydrogen bonds can interact with the microwave energy only to a limited degree because the electric dipole rotating effect is diminished as a result of the inter-molecular electric effects of the hydrogen bonding.

An obvious advantage of microwave drying is that the water molecule is heated directly and more than is the cellulose molecule, thereby greatly increasing its agitation and consequently its diffusive mobility through and out of the wood.

Microwave absorption has been used for a number of years in the wood products industry for such purposes as drying wood and curing glues. But until recently technology and costs have prevented the economical manufacture of small, portable microwave processing units. The development of an economical magnetron has made possible the small ovens suitable for home and laboratory. Such ovens are now widely available and in use.

The authors are research scientists of the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Berkeley, Calif., stationed at the Forest Fire Laboratory, Riverside, Calif.

USSR, from p. 23

Throughout our entire 2-week stay in the USSR we received excellent treatment and the program met our full approval. All details concerning personal comfort, meals, lodging, and transportation were looked after for us by our Soviet hosts.

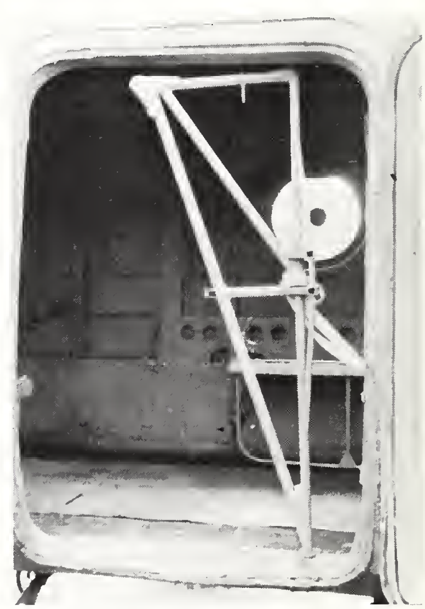
We have seen that the USSR is advanced in several areas of fire control such as:

- General use of a large helicopter initial attack system including the descent mechanism and highly trained and motivated smoke chasers.
- Use of explosives for line building in remote areas where water or bulldozers are not available.
- Forest protection organization supported by a large meteorological organization supplying the necessary weather data.
- Standard communications system across the country (although some Canadian fire control agencies operate superior systems—there is no standardization as in the USSR).
- Cloud seeding operation that is nearly operational and likely a significant new tool for large fire suppression.
- Prevention program that appears to be broad in scope and to make excellent use of young people.

In general, USSR fire control personnel appear to have a high degree of training and motivation and relatively low staff turnover. Their permanent year-round employment policy likely has some bearing on the moral of their personnel.

We came back with a great deal of knowledge—not only about the fire control system of the USSR, but about specific aspects of it that could be applied in Canada. Future exchanges of limited numbers of specialists on a long-term basis will help to fill in the many missing details. The forest fire problems of Canada and the USSR are surprisingly similar, and both countries have developed fire control technology in ways that will complement the other's total system.

Russian Hellattack descent mechanism and protective clothing.



Pivoting frame in open door of Russian helicopter for attachinc helicattack descent tape.

Do It Yourself Fire Prevention

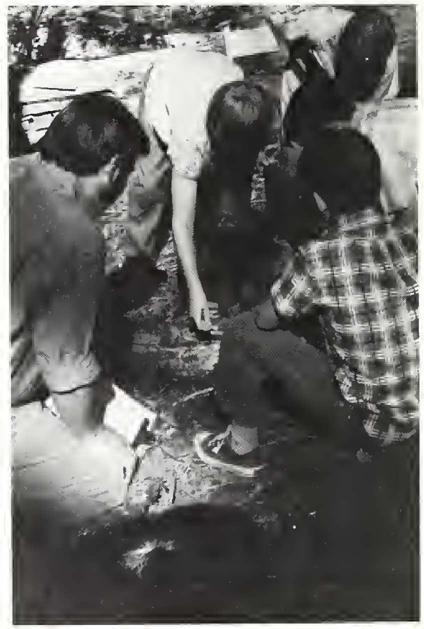
Bill Cecil and Carey Conway

Each year in and around many of our communities, numerous wildfires are started by children playing with matches or other forms of fire. Each year Forest Service District fire prevention personnel head out on the "kiddie" trail to try and convince thousands of young people that messing around with fire is a bad thing.

Maybe we are talking too much. How about trying this approach?

In the spring of 1973, Carey Conway and Bill Cecil of Weaverville Ranger District, Shasta-Trinity National Forests, designed a fire prevention program for 9- to 11-year old children. Basic objective of this new program was to explain the safe use of fire in the forest, emphasizing how to handle matches, how to build a small fire, and what materials would burn.

Facilitator Tomasini watches children ignite rotten wood to determine its burning characteristics.



Children work in groups of 7 to 10. Facilitator John Tomasini passes out task cards. Note Facilitator is not wearing uniform; this reduces the dominance of the facilitator and helps discourage unwanted questions.

Task Card Approach

This program was structured on the environmental education task card approach (see example). Children were asked to do certain tasks and then discuss the reasons and results of what they had done. This method stresses "doing" as a way to learn. Children were busy for several hours dropping matches, building fires, and discussing the reasons why fire did what it did and what part they played in the natural scene.

The supplies needed for this are minimal, but the instructors, or as they are called, "facilitators" are key to the success of the program. One who "facilitates" just helps keep the children moving from task to task with stimulating questions and a solid idea of the objectives of this type program. People who *must* give answers are not good facilitators.

Anyone who has gone through the Forest Service Environmental Education training session should have the techniques for good facilitating. Someone who can be trained easily to stand back, look and listen, also could do the job.

Bill and Carey with the blessings of Gene Gould, District Fire Control Officer have worked up a package with "Facilitator Tips", task cards, lesson plans and some of the thinking that went into this program.

Bill is also busy keeping records to see if child-caused fires drop and if those children who are involved in district fires, have been through the program.

Sample Task Card Questions

TASK B: Pick a partner with a watch. Light a match safely and drop it into this upper forest layer and record the following:

How many times did you drop the match before the fire started?

____

____

____

How many seconds did it take the fire to start?

____

Why does the material burn so well?

____

____

____

Facilitator Skip Conley turns a question from a child back to the child for answering by experimentation.

Partnership for Efficiency

Michael Bowman and James McLean

The 1972 fire season is history, but it dramatically illustrated the duplication of attack forces and logistical support which existed in northeastern California between the Bureau of Land Management, the Forest Service, and the California Division of Forestry.

Although a close working relationship existed between the agencies, improvement in Fire Dispatch coordination was urgently needed.

R. Michael Bowman, Chief, Division of Operations, Bureau of Land Management, Susanville, California. James McLean, Fire Management Officer, Lassen National Forest, Susanville, Calif.

The situation called for a creative approach to fire resource allocation.

After the basic agreement was approved plans were formulated and implemented to build the Interagency Fire Dispatch Center in Susanville. A detailed plan for operation was written to guide the management and decision making process within the Susanville Interagency Fire Dispatch Center (SIFDC). The Operating Plan was organized into three broad sections.

Mobilization Plan—Describes details of the BLM-Susanville district and Lassen National Forest organizational structure, fire responsibilities, protection objectives, available resources, and dispatching procedures.

Finance Plan—Assigns and distributes the operating cost of the Dispatch Center on an equal basis to cooperators.

Training Plan—Schedules joint training sessions and establishes procedures for use of training materials.

The organizational flow for decisions and information was designed with as few encumberances on the dispatchers authority as possible. During a normal initial attack situation (single fire report, fig. 1), the Dispatch Center initiates action on the fire by responding with the closest and most economical suppression force. With time of attack and economics as basic guide posts, organizational boundaries become insignificant. Buildup of initial at-

tack strength is coordinated to meet resource management objectives by integrating weather, resources values, and environmental constraints in the area dispatch plans. Once the initial attack action is started the fire information is given to the respective fire management personnel involved.

When a multiple-fire situation or multi-agency fire occurs, the Dispatch Center becomes an intelligence gathering and communications body. (multiple-fire problem, fig. 2) A multi-agency coordinating group is established to set priorities based on intelligence gathered by the dispatch center. Going fire intelligence or new fire reports are given to the Dispatch Center. New fire starts are acted upon within the remaining initial attack capability or that allocated by the coordinating center. If additional resources are needed to meet a project fire or initial attack situation, the request is passed to the *Coordinating Center* which determines priorities on total local resources and if it is necessary to go outside of the local area for support. If local resources are exhausted the next level of support is the North Zone Dispatch Center in Redding, Calif. If resources are exhausted within California, then the Boise Interagency Fire Center is contacted for a screening of national resources. Therefore, the Coordinated Action Plan is structured to allow top management an input into major suppression activities and an opportunity to coordinate resource allocation with other priority programs.

Six months from the inception of the multi-agency proposal the Susanville Interagency Fire Dispatch Center was operational. The Center is equipped with local BLM and Forest Service radio systems, service net to North Zone Dispatch Center, fire weather computer, and a versatile telephone system. The Center is manned with three permanent dispatchers and a temporary clerk dispatcher. With limited training and familarization on interagency procedures the Dispatch Center organization moved into action with the first fire occurring on April 12, 1973. Veteran Forest Service Dispatchers Vern Kasper and William Ott quickly adapted to the Interagency concept and paved the way for smoothing up the operational defects encountered in the

Initial Attack Plan.

By mid August the Center had successfully passed the test of the initial attack phase of the program. The summer of 1973 was breaking long standing drought records and the Center was dispatching manpower and equipment to fires in other areas of California and in support of the Boise Interagency Fire Center for fires in the Northwest.

The Susanville District, BLM, and the Lassen N.F. had reached minimum local manning levels by mid August because of off-unit support activities. An analysis of fire weather confirmed that August 19 had all of the characteristics of a red flag day. After conferring with the BLM and Forest Service fire management staffs, the Dispatch Center took action to assure that all fire crews were at full manning levels and presuppression fire equipment was in place.

They alerted North Zone of potential support needs. At 1235 hrs., August 19, the Nine Mile fire was ignited by a carbon exhaust particle from a rural home owners vehicle. Within 3 minutes the fire had been reported by BLM and CDF lookouts. The Dispatch Center committed the initial attack forces and North Zone Dispatch Center responded with a priority release of air tankers from going fires. Heavy fuels and 40- to 50-knot winds doomed the initial attack effort. However, this attack failure was quickly analyzed by the Dispatch Center and BLM Fire Control Officer Wandell Elliot who was on the scene.

A multi-agency effort was quickly implemented. BLM District Manager Dean Bibles and Forest Supervisor Jim Berlin were given an intelligence update of the fire situation. After an appraisal of the total regional fire problem, a local interagency fire team was assigned to the Nine Mile fire, arriving on the

Partnership, next page

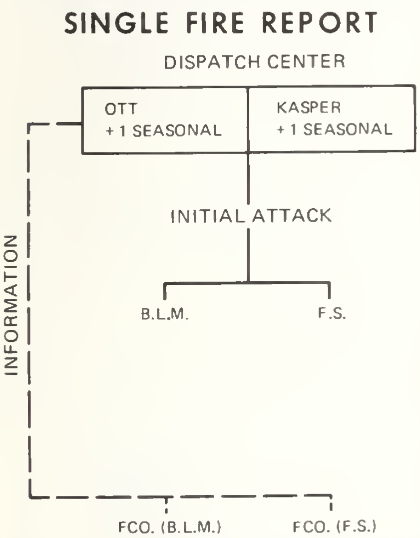


Figure 1—During a mornal initial attack, single fire report situation the Dispatch Center initiates action on the fire by responding with the closest and most economical suppression force.

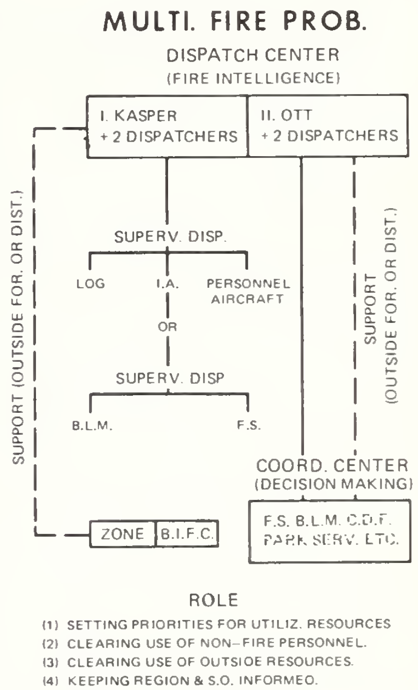


Figure 2—During a multiple fire situation the Center coordinates interagency resource needs.

Speedy, Safe System Used for Attaching Litter to Helicopter

Larry D. Nelson

A speedy and safe system for attaching a rescue litter basket externally to a G3B-2 helicopter is being used at the Interagency Base at West Yellowstone, Montana. The system was developed to handle an increasing number of rescues carried out by the Interagency Base.

Here are instructions and drawings used to train personnel for the system.

Figure 1.—Litter Attachment System can be attached to all small helicopters with or without baskets mounted on the cross tubes. Nylon straps should pass under the cross tubes behind the vertical leg. It is also permissible to pass the strap under the permanently mounted basket.

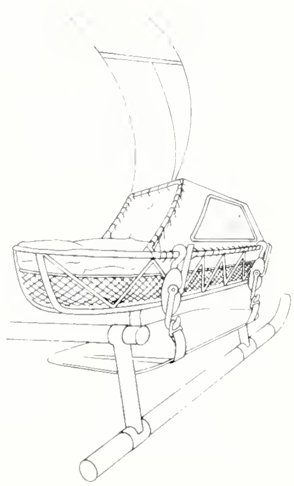


Figure 2.—Pass the V-Ring end of nylon strap around top edge of litter, near head and feet, and snap.

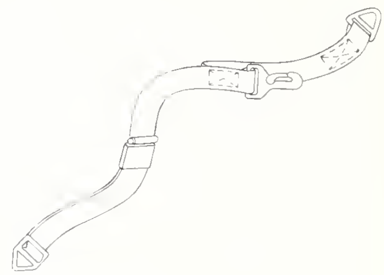


Figure 3.—V-Ring and Snap attached to Litter.

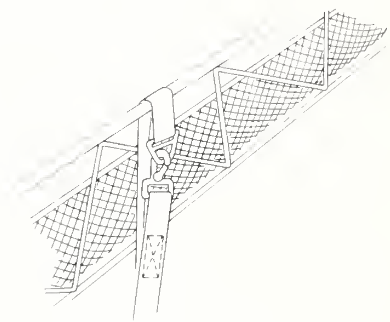
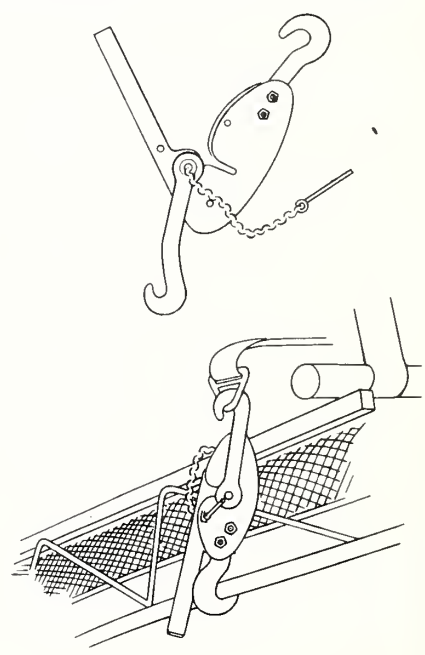


Figure 4.—Hook end of binder to the litter. Hook loose end of binder into adjustable V-ring on nylon strap and pull all the slack out of the strap through adjustable V-ring.



Partnership, from p. 27

fire scene 2½ hours after initial attack. Local management followed up the overhead assignment and established priorities for utilization of resources. North Zone moved to meet support needs. After two burning periods the Nine Mile fire was controlled at 19,500 acres. However, an intensive fire management analysis indicated that although there were the reoccurring problems related to an extra-period fire, the interagency assignment of resources had been effective in mobilizing for control of the fire.

The seasonal fire activity for the SIFDC ceased in November with an impressive first year record. The experience gained during the initial operation of the Dispatch Center is now being applied to other operational areas on the Susanville District, BLM, and Lassen National Forest where duplication exists. The training function offers many opportunities for increased efficiency due to the remote location of Susanville. Joint planning has made it possible to bring a broader scope of training and a higher quality of training to employees with a cost savings. Interagency fire qualification committees consisting of representatives of the local BLM and Forest Service offices review the qualifications of all fire personnel.

The input of the fire qualification committee will be utilized to develop training needs for standardizing personnel qualifications under the National Fire Qualification System. Fire cache and communication repair are being consolidated with strong management emphasis on reducing duplication of effort and increasing organizational flexibility.

Although the first year results of the experiment are gratifying, we do not pretend that this operation is a panacea for all interagency problems. Many factors have made the Susanville experiment a success. However, one common thread binding it together through many crises was the commitment of top management.

As managers we often become so provincial that we ignor our total responsibility to the public. Hopefully, on-the-ground operations such as the SIFDC will chart a course to significantly improve our Public Land Administration.

Recent Fire Research Publications

These publications are available from various offices of the Forest Service and private organizations. If you would like to obtain a copy, write to that office indicated in parenthesis at the end of the citation, e.g. (INT), Intermountain Forest and Range Experiment Station.

Anderson, H.E.
1968. Sundance Fire: an analysis of fire phenomena. USDA Forest Serv. Res. Pap. INT-56, 37 p. (INT)

Anderson, H.E.
1968. Fire spread and flame shape. Reprint from Fire Technology, 4(1): 51-58. (INT)

Anderson, H.E.
1970. Forest fuel ignitability. Reprint from Fire Technology, 6(4):312-319, 322. (INT)

Anderson, H.E., A.P. Brackebusch, R.W. Mutch, and R.C. Rothermel.
1966. Mechanisms of fire spread research progress report No. 2. U.S. Forest Serv. Res. Pap. INT-28, 29 p. (INT)

Beaufait, William R.
1965. Characteristics of backfires and headfires in a pine needle fuel bed. USDA Forest Serv. Res. Note INT-39, 7 p. (INT)

Beaufait, William R.
1970. IFFRC symposium and retreat impressions. Reprint from The Role of Fire in the Intermountain West Proc., p. 212-214. (NFFL)

Beaufait, William R. , and William C. Fischer.
1969. Identifying weather suitable for prescribed burning. USDA Forest Serv. Res. Note INT-94, 7 p. (INT)

Brackebusch, A.P.
1972. Comments on the Denver Symposium retreat. Reprint from Fire in the Environment Symp. Proc. (NFFL)

Brender, Ernst V.
1973. Biological impact of damage to forests. Presented at Damage Appraisal Workshop, Univ. of Fla., Gainesville, Apr. 28. (SFFL)

Cooper, Robert W.
1973. Fire doesn't have to smoke. Prog. Farmer 88(2):79. (SFFL)

Cooper, Robert W.
1973. Beneficial and detrimental effects of forest fires. Presented at the Middle Atlantic Interstate For. Fire Prot. Compact, Cape Henlopen State Park, Del., Sep. 18-20. (SFFL)

Cooper, Robert W.
1973. Effects of prescribed fires and wildfires on air quality. Presented at Prescribed Burning Seminar for EPA and NFPA Charleston, SC, May 30-31. (SFFL)

Cooper, Robert W.
1973. Smoke management - needs and implementation opportunities. Presented at the Research Implementation Workshop, Atlanta, Ga., Jan, 15-19. (SFFL)

Adjustment must be tight but not so tight that damage is done to litter or helicopter. Once correctly adjusted, no further adjustment will be necessary.

Pull handle of binder up into locked position being careful to keep fingers clear.

Place safety pin in hole in binder, bend slightly so it will not come out. The pin is a safety device so binder can not come open in flight.

Larry D. Nelson is the Supervisory Fire Control Technician, Division of Fire Control Aerial Fire Depot, Forest Service, USDA.

Explosive Cord Tested for Safety and Durability

Continuing joint studies between the Naval Weapons Center (NWC) of China Lake, California, and the Missoula Equipment Development Center (MEDC) of the U. S. Department of Agriculture (Forest Service) have resulted in an explosive device capable of cutting useful fire lines under certain forest conditions.

Bare explosive charges will cut a fire line in grass, brush or forest litter, but unfortunately the use of untreated explosives in detonating devices such as detonating fuses, bangalore torpedos or explosive ropes will also ignite forest fuels. The fireline cord and proposed fireline cord detonator assembly were tested for safety and durability. Tests included bullet impact, burning, crushing, chopping, dragging, bending, air dropping, and effects of soaking in a common retardant solution.

In all cases the fireline cord, where damaged or destroyed by the test, failed to detonate as a result of damage or mishandling. The exploding bridge wire detonator assembly was found to perform satisfactorily. Standard drop tests were performed on the fireline cord's explosive filler which was found to be less sensitive than the untreated PETN of common detonating fuses.

Cooper, Robert W.
1973. Status of prescribed burning and air quality in the South. Presented at Tall Timbers Fire Ecology Conf., Mar. 22-23. Tallahassee, Fl. (SFFL)

Cooper, Robert W.
1973. The trade-offs between smoke from wild and prescribed forest fires. Presented at the International Symposium on Air Quality and Smoke From Urban and Forest Fires, Colorado State Univ., Fort Collins, Colo., Oct. 24-26. (SFFL)

Countryman, C.M., M.A. Fosberg, R.C. Rothermel, and M.J. Schroder.
1968. Fire weather and fire behavior in the 1966 Loop Fire Reprint from Fire Tech. 4(2):126-141. (NFFL, PSW)

Furman, R. William, and Robert S. Helfman
1973. A computer program for processing historic fire weather data for the National Fire Danger Rating System, USDA Forest Serv. Res. Note RM-234 12 p. (RM)

Fuquay, D.M. and R.G. Baughman.
1972. Lightning discharges that caused forest fires. Reprint from Jour. of Geophysical Research, 77(12):2156-2158. (NFFL)

George, Charles W., and Ayimer D. Blakely.
1973. An evaluation of the drop characteristics and ground distribution patterns of forests fire retardants. USDA Forest Serv. Res. Pap. INT-134, 60 p. (INT)

Grelen, H.E., and H.G. Enghardt.
1973. Burning and thinning maintain forage in a longleaf pine plantation. J. For. 71:419-420, 425. (RSS)

Grelen, H.E. and L.B. Whitaker.
1973. Prescribed burning rotations on pine-bluestem range. J. Range Manage. 26(2):152-153. (RSS)

Habeck, James R.
1972. Fire ecology investigations in Selway-Bitterroot Wilderness. USDA Forest Serv., Northern Region Pub. R1-72-001. (R-1)

Habeck, James R.
1973. A phytosociological analysis of forests, fuels, and fire in the Moose Creek Drainage, Selway-Bitterroot Wilderness, USDA Forest Serv., Northern Region Pub. No. R1-73-022. (R-1)

Haines, Donald E., William A. Main, and John S. Crosby.
1973. Forest fires in Missouri USDA Forest Serv. Res. Pap. NC-87, 18 p. (NC)

Hirsch, Stanley N.
1971. Application of infrared scanners to forest fire detection. Reprint from INT Workshop Earth Resources Surv. Syst. Proc., vol. 2:153-169. (NFFL)

Honeywell, Inc.
1973. High altitude retardant drop mechanization study, Vol., I & II. (NFFL)

Howard, E.T.
1973. Heat of combustion of various southern pine materials. WOOD SCI. 5:194-197. (RSS)

Johnston, William F.
1973. Tamarack seedlings prosper on broadcast burns in Minnesota peatland. USDA Forest Serv. Res. Note NC-153, 3 p. (NC)

Kickert, Ronald N., Alan R. Taylor, and Mark H. Behan.
1973. Fire ecology project research plan for 1973. Internal Report 124. Fire Ecology Project, Coniferous Biome, IBP, Univ. of Mont., 17 p. mimeo. (IBP,UM)

Intermountain Fire Research Council.
1970. The role of fire in the Intermountain West. (for sale by Secretary, IFRC, 2705 Spurgin Road, Missoula, Mont. $4.00). (IFRC)

Lindenmuth, A.W., jr., and James R. Davis.
1973. Predicting fire spread in Arizona's oak chaparral. USDA Forest Serv. Res. Pap. RM-101, 11 p. (RM)

Loomis, Robert M.
1973. Estimating fire-caused mortality and imjury in oak-hickory forests. USDA Forest Serv. Res. Pap. NC-94, 6 p. (NC)

Lyon, L. Jack.
1966. Initial vegetal development following a prescribed burning of Douglas-fir in Idaho. USDA Forest Serv., Res. Pap. INT-29, 17 p. (INT)

Lyon, L. Jack.
1969. Wildlife habitat research and fire in the northern Rockies. Reprint from Proc. Tall Timbers Fire Ecol. Conf. 9:213-227. (FSL, Msla.)

Lyon, L. Jack, and Peter F. Stickney.
1966. Two forest fires and some specific implications in big game habitat management. Reprint from Proc. Ann. Conf. Western Assoc. State Game and Fish Comm. 46:181-193. (FSL, Msla)

Lyon, L. Jack, and W. Leslie Pengelly.
1970. Commentary on natural role of fire, p. 81-84. Reprint from Symp. The Role of Fire in the Intermountain West. INT Fire Res. Coun., Missoula, Mont. 229 p. (FSL, Msla)

McCammon, Bruce P., and David A. Rainey.
1973. Fire-danger index generation. Hewlett-Packard Keyboard. 5(1):17-18. (RM)

Madden, Forrest H.
1971. A new system for detecting latent forest fires. Reprint from Region Six Conf. Inst. Elec. and Electron. Eng. Proc. 1971: 8 p. 6B-2 (NFFL)

Madden, Forrest H.
1973. Performance requirements for airborne infrared forest fire surveillance equipment. USDA Forest Serv. Res. Note INT-167, 7 p. (INT)

Mobley, Hugh E.
1973. Fire behavior and planning for initial attack. Presented at the Middle Atlantic Interstate Forest Fire Protection Compact, Cap Henlopen Stat Park, Del., Sep. 18-20. (SFFL)

Mobley, Hugh E.
1973. Summary of State regulations as they affect open burning. Presented at International Symposium on Air Quality and Smoke From Urban and Forest Fires, Colorado State Univ., Fort Collins, Colo., Oct. 24-26. (SFFL)

Mobley, Hugh E., and Ed. Kerr.
1973. Wildfire versus prescribed fire in the southern environment Southeast. Area, S&PF, Jul., 6 p. (SFFL)

Mobley, Hugh E., et al.
1973. A guide for prescribed fire in southern forests. Southeast Area. S&PF-2 40 p. (SFFL)

Mutch, Robert W.
1970. Wildlife fires and ecosystems: a hypothesis. Reprint from Ecology, 51(6):1046-1051. (NFFL)

Noste, Nonan V.
A Field Method for Measuring Patterns of Water Dropped from Helicopters. USDA Forest Serv. Res. Note PNW-202 July 1973, 11 p. (PNW)

Philpot, Charles W.
1973. The changing role of fire on chaparral lands. (Mimeo.) Paper presented at Symp. Living with the Chaparral, Univ. of California, 15 p. (NFFL)

Pharo, James A.
1973. A fuel factor development based upon air-quality criteria. Presented at the Prescribed Burning Seminar for EPA and NFPA, Charleston, SC, May 30-31. (SFFL)

Pharo, James A.
1973. An interim smoke management guide for the South. IN:Natl. Fuel Manage. Workshop Proc., Marana, Ariz., Jan. (SFFL)

Roe. Arthur L., William R. Beaufait, L. Jack Lyon, and Jerry L. Oltman.
1971. Fire and forestry in the northern Rocky Mountains—a task force report. Reprint from Jour. of For. 68(8):464-470. (NFFL, JF)

Rothermel, R.C.
1972. A mathematical model for predicting fire spread in wildland fuels. U.S. Forest Serv. Res. Pap. INT-115, 40 p. (INT)

Rothermel, R.C., and Charles W. Philpot.
1973. Predicting changes in chaparral flammability. Reprint from Journal of Forestry, Oct. 1973:640-643. (NFFL, JF)

Roussopoulos, Peter J., and Von J. Johnson.
1973. Estimating slash fuel loading for several Lake States tree species. USDA Forest Serv. Res. Pap. NC-88, 8 p. (NC)

Sackett, Stephen S.
1973. Prescribed fire technology for minimizing smoke hazards. Presented at International Symposium on Air Quality and Smoke From Urban and Forest Fires, Colorado State Univ., Fort Collins, Colo., Oct, 24-26. (SFFL)

Seltzer, Theodore S.
1973. Logging residues on harvesting operations western South Dakota, Wyoming, Utah, and Colorado. USDA Forest Serv. Res. Pap. INT-135. (INT)

Slaughter, Charles W., Richard J. Barney, and George M. Hansen.
1971. Fire in the northern environment, a symposium proceedings. USDA Forest Serv. (PNW)

Taylor, Alan R.
1969. Lightning effects on the forest complex. Reprint from Proc. Annual Tall Timbers Fire Ecology Conf., p. 127-150. (NFFL)

Taylor, Alan R.
1964. Lightning damage to forest trees in Montana. Reprint from Weatherwise, 17(2):60-65. (NFFL)

USDA Forest Service.
1973. The CL-215: Summary of its performance as an air tanker. 57 p. Wash., D.C.

USDA Forest Service, Northern Region.
1972. The natural role of fire. Pub, No. R1-72-033. (R-1)

USDA Forest Service, Northern Region.
1973. Forests born of fire, Pub. No. R1-013. (R-1)

Wade, Dale D.
1973. Logging residues disposal hazards in Georgia's Piedmont. South. Lumberman 226 (2802):15-18. (SFFL)

Wade, Dale D. and Darold E. Ward.
1973. An analysis of the Air Force Bomb Range Fire. Southeast For. Exp. Stn., USDA Forest Serv. Res. Pap. SE-105, 38 p. (SFFL)

Wellner, Charles A.
1970. Fire history in the northern Rocky Mountains. Reprint from The Role of Fire in the Intermountain West. (INT)

Williams, Dansy T.
1973. Project THEO Report 1971-1972. Southeast Forest Exp. Stn. USDA Forest Serv., 36 p.

Williams, Dansy T.
1973. Prescribed fire, weather intelligence, and air quality. Presented at Prescribed Burning Seminar for EPA and NFPA, Charleston, SC., May 30-31. (SFFL)

Wilson, Ralph A., S.N. Hirsch, B.J. Losensky, and F.H. Madden.
1971. Airborne infrared forest fire detection system: final report. USDA Forest Serv. Res. Pap. INT-93, 99 p. (INT)

Availabilty Code

INT. . . . Intermountain Forest & Range Experiment Station, 507 25th Street, Ogden, Utah 84401.

NFFL. . . . Northern Forest Fire Lab., Drawer G., Missoula, Mont. 59801.

IBP. . . . Fire Ecology Project, US/IBP Coniferous Biome Science Comples 444 University of Montana, Missoula, Mont. 59801.

UM. . . . University of Montana, School of Forestry, Missoula, Mont. 59801.

R-1. . . . USDA, Forest Service, Northern Region, Federal Building, Missoula, Mont. 59801.

PNW. . . . Pacific Northwest Forest & Range Experiment Station, 809 NE6th Ave., P.O. Box 3141, Portland, Oreg. 97208.

PSW. . . . Pacific Southwest Forest & Range Experiment Station, 1960 Addison Street, P.O. Box 245, Berkeley, Calif. 94701.

JF. . . . Journal of Forestry

Coming in October
Fire Management Conferences

Three fire management and fire ecology conferences will be held in the Pacific Northwest during October—at Missoula; Portland; and Vancouver, British Columbia.

Chief of the Forest Service, USDA, John R. McGuire, will be the featured banquet speaker at the Missoula meeting. Sponsored jointly by the Intermountain Fire Research Council and Tall Timbers, this meeting will be held October 8-10. The program includes major sections on fire management, fire ecology, and fire use.

The Portland meeting, being sponsored jointly by the University of Washington, Oregon State University, and Tall Timbers, will be held October 16-17 at the Western Forestry Center. The first half-day of the Portland meeting will be on history and ecology, the second half-day on environmental considerations, and the third day on land management integration of ecology and environmental considerations.

Fire Management will be discussed for both the United States and Canada, with special focus differences in management between intensively used areas and wilderness areas. Other topics to be covered will be fire in the Selway-Bitterroot Wilderness and the Northern Rocky Mountain National Parks, the relationship of fire to wildlife and habitat, and fire use in relation to soil fertility, stand regeneration, effects on small mammals and the atmosphere.

The third meeting will be sponsored jointly by Tall Timbers and the University of British Columbia on October 24-26. The first 2 days will cover ecology, fire history, and fire management throughout Canada. A field trip is planned for the 26th.

For information contact:

Art Brackebusch
Forest Service, U.S. Department of Agriculture
Drawer G
Missoula, Montana 59801

Bob Martin
University of Washington
4000 15th Avenue, NE
Seattle, Washington 98105

Bob Henderson
School of Forestry
University of British Columbia
Vancouver, B. C.